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The

Tropical Agriculturist

FEBRUARY, 1941

EDITORIAL

RESEARCH

CONSIDERABLE differences of meaning are attached to the word "Research" and many people have incorrect ideas as to the functions of the research worker. In the Report on Agricultural Research in Great Britain published in 1938 by P. E. P. (Political and Economic Planning) there is a classification of research activities which should go far to clarify ideas on the subject.

The following is P. E. P.'s classification of research activities as applied to agriculture :—

(i.) Background research is the pursuit of knowledge for its own sake, the investigation of the fundamental scientific laws that underly all agricultural and industrial enterprise. This is the function of the universities.

(ii.) Basic research is the study of broad subjects with a pronounced practical bearing such as parasitology and animal genetics. This is the recognized sphere of the research institutes.

(iii.) *Ad hoc* research is the study of specific practical problems such as the control of foot and mouth disease, and is also the function of the research institutes though a considerable amount is done by the provincial advisory staffs and privately.

(iv.) Pilot or Development research bridges the gap between laboratory experiment and commercial practice, as in the growing of new strains of plants. It is done at some research institutes, as well as at agricultural colleges, farm institutes and private research stations.

That very interesting classification has been made with particular reference to Great Britain. It is of interest and value to compare the state of research work in a small country like Ceylon with much smaller financial resources.

The background research worker requires the calm atmosphere of the University where he can pursue his work free from disturbing demands for results. Even in a university little can be expected in the way of background research where a great part of the worker's time has to be devoted to routine teaching of his subject. To a great extent such work will have to be done in the larger universities in more wealthy countries.

Basic research : So far as agriculture is concerned we have in Ceylon three separate research institutes each concerned with a specific crop namely Tea, Rubber, and Coconut and a small number of research officers in the Department of Agriculture concerned with a multiplicity of crops and animals. Even our "one crop" research institutes cannot devote much time to purely basic problems on account of shortage of staff. This is even more true of the research officers of the Department of Agriculture.

Ad hoc research : In a small country such as Ceylon it is seldom possible for a research worker or a group of workers to devote whole time altogether to one specific problem. It is this whole time devotion to a problem which is productive of results. It is probable that better results would be obtained, where the number of workers is limited, if the temptation to attack a large number of pressing problems was deliberately resisted and attention focussed entirely on a few problems. It must be remembered that the days are past when the general worker in some particular field could be expected to produce numerous results of practical value. The pioneer workers had a virgin field and made full use of their opportunity. Their successors find the more recondite and abstruse problems still awaiting solution.

Pilot or Development research : To a large extent in small countries this must remain the main branch of research work.

The worker in a small country must have the opportunity to keep in touch with the work of the larger institutes by visits, and by wide reading of literature emanating from these institutes. His work is then to sift out from the mass of material available those results and findings which may be of value to his country, to test the findings under local conditions and to pass on those results which prove of value. Very elaborate laboratory accommodation is probably of less importance for such work than good facilities for testing out results obtained by workers in other countries.

PROFILE
OF
A LATERITE (CABOOK) QUARRY

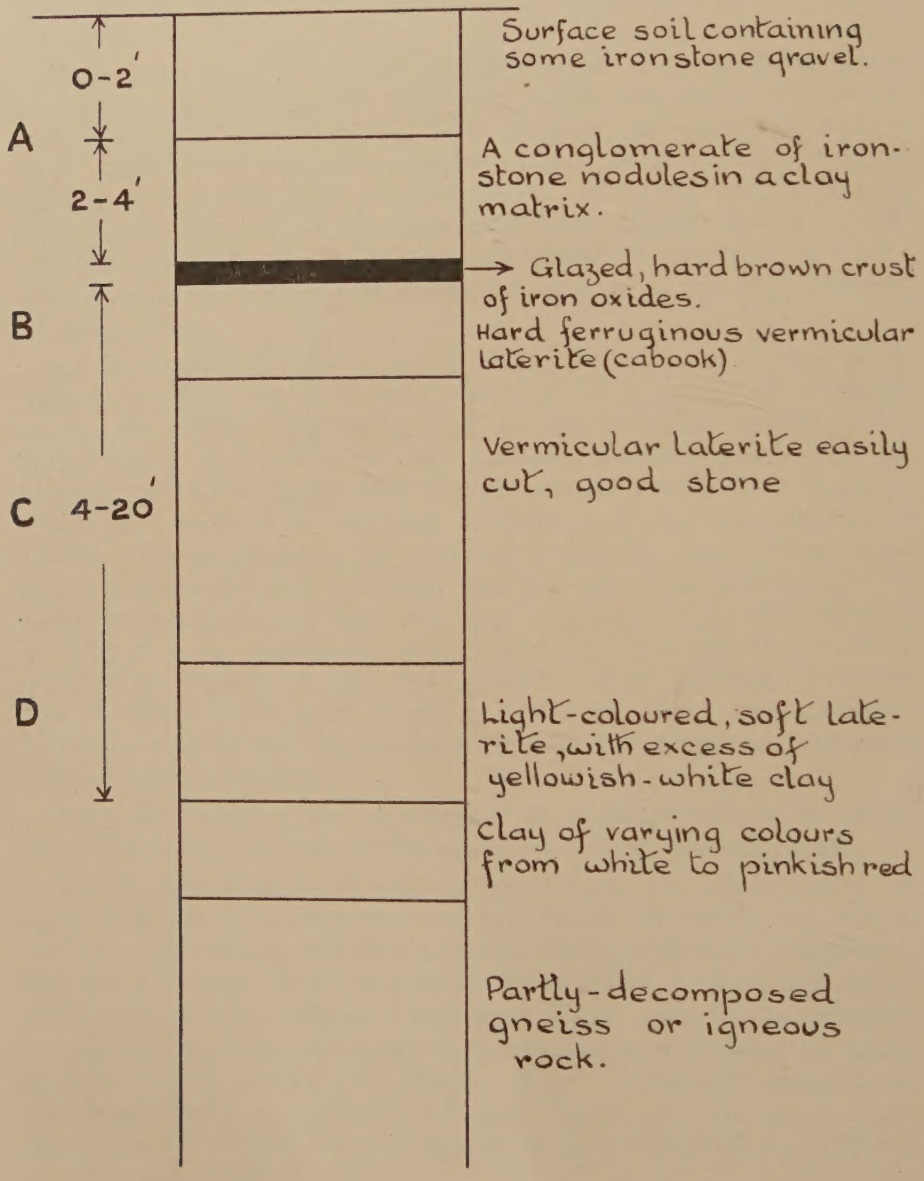
0-2'
A
2-4'
B
C 4-20'
D
Surface soil containing some ironstone gravel.
A conglomerate of ironstone nodules in a clay matrix.
Glazed, hard brown crust of iron oxides.
Hard ferruginous vermicular laterite (cabook)
Vermicular laterite easily cut, good stone
Light-coloured, soft laterite, with excess of yellowish-white clay
Clay of varying colours from white to pinkish red
Partly-decomposed gneiss or igneous rock.

PLATE I.

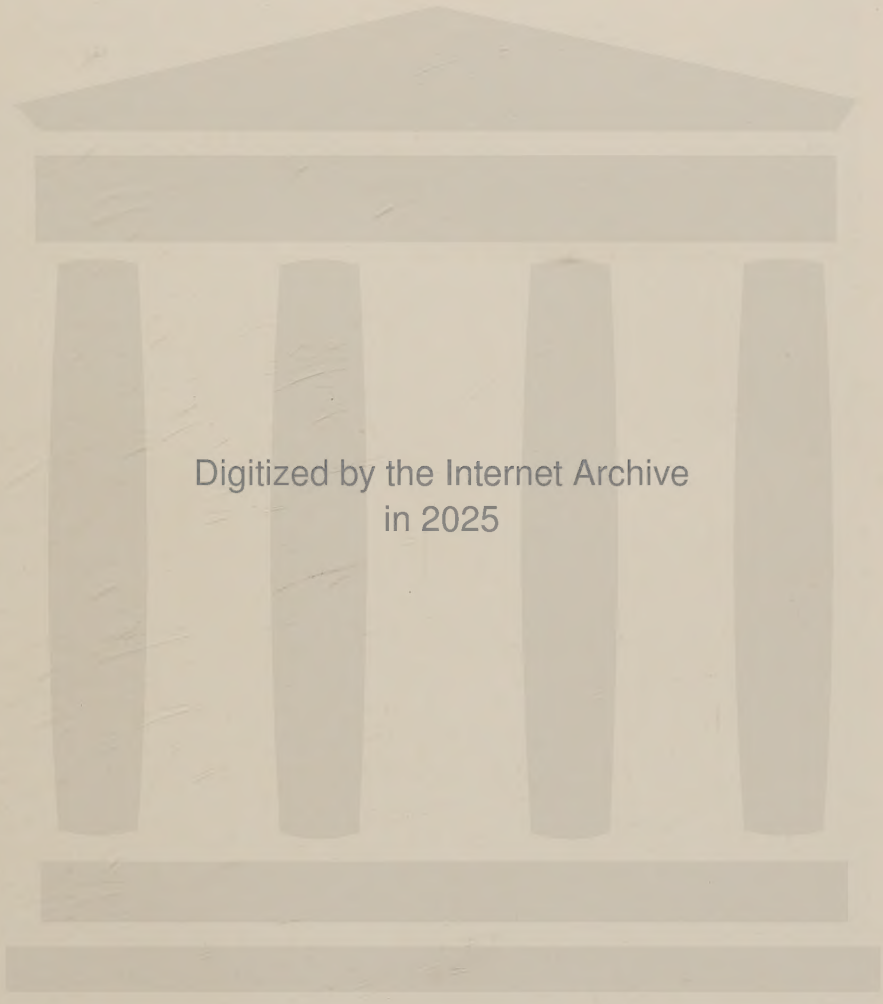

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PLATE II.—PROFILE OF A LATERITE (CABOOK) QUARRY.

STUDIES ON CEYLON SOILS

XV. THE COMPOSITION OF SOME LOCAL LATERITES (CABOOKS), SOIL CONCRETIONS AND CLAYS

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AND

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IN this paper of the series on Ceylon Soils, data are furnished on the analytical composition of samples of the building stone known locally as *cabook*, and for which material the name laterite was first used by Buchanan in India in 1807. The samples were obtained from different sections of three representative quarries situated in the coastal belt of the humid low-country of the Island. The rocks from which the laterite is derived are Charnockites or intermediate gneisses. Several analyses of local laterite had previously been made by Bamber and Bruce (1), but so far as could be ascertained, no investigations were made on the variation in composition of samples obtained from different depths of a quarry. It is not proposed in this article to discuss the controversial question of the origin of laterite or the present state of our knowledge on the subject. All that is attempted is a discussion of the results of the analyses shown in Table I., and the deduction of such conclusions as would appear to be warranted from the data. In order, however, to afford readers, particularly of other countries, some idea of the nature and occurrence of local laterite, a profile of a cabook quarry is graphically represented in Plate I and a photograph shown in Plate II. The details of the profile need no further elaboration but it would suffice to state that cabook corresponds in every detail with the material described as "laterite" by Buchanan (2), Oldham (3), Richthofen (4), &c., in India and other tropical countries. Not every type of laterite is used as a building stone in Ceylon. Less indurated clays showing the morphological characteristics of cabook but lacking the cohesive properties of the latter, occur all over the wet zones of the Island or in the lower horizons of cabook pits. This soft laterite material is, under certain conditions, cultivated with rubber, tea,

coconut, cinnamon, and garden crops with varying degrees of success. A typical profile of such a soil is described and its analytical composition shown in Table (I).

In order to make these studies more complete, the analysis of a sample of ferruginous concretions or pisolites (known as *perdigon* in Cuba) collected from the uppermost horizon of the laterite soil profile is furnished in Table III., which also includes, for purposes of comparison, the analyses of different types of soil concretions from various parts of the Island. In Table IV. the analyses of some local clays are presented. In all centres but Peradeniya, the clay occurs in sufficient quantity to make its commercial exploitation possible.

ANALYTICAL METHODS

In the case of laterites, the samples were carefully selected and finely ground down. Harrison's (5) tri-acid digestion method, which permits of the separate determination of free and combined silica, was adopted. Free iron was estimated by Drosdoff and Truog's method (6). An indication of the aluminium hydroxide or hydrated oxide contents of certain samples was obtained by the analysis of hydrochloric acid extracts of the materials, as recommended by Bauer, Lenz and others (4). The ordinary fusion method of analysis was adopted in the case of the clays and soil concretions. Combined water, iron, aluminium and titanium oxides were determined in all samples ; magnesium, calcium and manganese oxides in such samples as were likely to contain these in appreciable amounts.

CEYLON LATERITES

(For Table I. see page 69)

The analyses of nine samples of laterite and one of the yellowish-white clay material obtained from the interstices of a low-depth sample are shown in Table 1. The locations of the pits and the depths from which the samples were obtained are also indicated. It will be noted from a reference to the table that in general :

(1) The combined water contents increase as the depth of sampling increases, pointing to a greater proportion of hydrated oxides being present in the lower horizons of the pit.

(2) The combined silica percentages are fairly high in the six samples examined. They are from two to three times as high as the free silica contents. Total, combined and free silica all increase with depth.

(3) The alumina contents vary from 23·5 to 30·7 per cent. These figures are low when compared with those of Indian laterite samples derived from basic rocks or even of certain local samples, but are not very different to those of the laterites of

TABLE I.

Laterite (Cabook) Profile

Location.	Dalugama, W. P.			Horagalla, W. P.			Maharagama, W. P.			
	B 5′–7′	C 7′–11′	D Below 11′	B 2′–4′	C 4′–8′	D Below 8′	B 2′–4′	C 4′–8′	D Below 8′	Yellowish-white clay material in the interstices of D
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Loss on ignition ..	13·56	14·04	15·08	14·99	15·33	15·35	15·09	15·61	16·66	18·74
Silica — Total ..	33·84	35·22	40·40	34·64	40·06	43·00	30·99	33·83	35·45	31·60
Silica — Free ..	8·34	8·06	9·50	11·86	12·42	14·11	—	—	—	—
Silica — Combined ..	25·50	27·16	30·90	22·78	27·64	28·89	—	—	—	—
Alumina and titanium oxide ..	25·37	30·22	30·74	24·37	29·36	29·81	23·54	27·61	28·33	32·26
Iron oxide — Total ..	26·73	19·68	13·16	26·93	13·44	11·19	18·95	13·44	10·30	3·73
Iron oxide — Free ..	12·87	10·45	6·19	13·06	7·46	4·11	—	—	—	—
Iron oxide — Combined .	13·86	9·23	6·97	13·87	5·98	7·08	—	—	—	—
Total silica/sesquioxide (molecular) ..	1·31	1·39	1·75	1·42	1·79	1·97	1·47	1·58	1·72	1·54
Combined silica/sesquioxide (molecular) ..	1·02	1·08	1·34	0·93	1·23	1·33	—	—	—	—
*Total silica/alumina (molecular) ..	2·25	2·02	2·07	2·37	2·34	2·44	2·23	2·08	2·12	1·66
*Combined silica/alumina (molecular) ..	1·70	1·53	1·71	1·58	1·59	1·64	—	—	—	—
*Alumina/iron oxide (molecular) ..	1·48	2·40	4·79	1·41	3·41	4·16	1·94	3·21	4·30	1·33

Malabar and Kanara (8). Bamber and Bruce (1) found a variation of alumina in local samples from 22·9 to 62·0 per cent. Many of their samples, however, had alumina contents of less than 35 per cent. The alumina contents increase with depth in all cases. This is the reverse of the iron percentages which fall as the depth increases. Thus in the case of the Dalugama pit, the alumina/iron oxide ratios increase from 1·5 to 4·8 as the depth increases from 5 to 11 ft.

(4) The iron oxide contents of the samples vary appreciably, *viz.*, from 10·3 to 26·9 per cent; but a greater variation was found by Bamber and Bruce, the range in their analyses being 4·0 to 29·0 per cent. In the present samples it is interesting to note that the free and combined iron oxides occur in about equal proportions.

(5) The yellowish-white clay material is relatively rich in alumina and has a very low iron content.

The above findings are generally in conformity with those of Oldham (3), Blandford (7) and others.

The analysis of the hydrochloric acid soluble fraction of three samples of laterite shown below indicate that a proportion of the alumina in laterite exists as hydrated oxide or hydroxide. This is in conformity with the findings of previous workers, Lenz, Bauer and others (4), supported by Bamber and Bruce.

Sample.	B Per cent.	D Per cent.	White clay material from D Per cent.
Insoluble in acid	54·30	55·43	57·73
*Soluble in acid	45·70	44·57	42·27
*Containing :—			
Combined water	15·97	16·03	19·11
Alumina (Al_2O_3)	8·88	16·39	19·17
Iron oxide (Fe_2O_3)	20·81	12·05	3·95

GENERAL DISCUSSION

What is obvious from these analyses and those of other workers is that laterite varies greatly in composition, which is dependent on (*a*) the rock from which the sample is derived, and (*b*) the depth from which it is taken. In view of this marked variation in composition, the classification of soils into laterite, lateritic and non-lateritic types on the basis of chemical criteria alone, *e.g.*, the silica/alumina ratios of the clay fraction, is likely to be misleading. This is clearly seen in the present analyses. In no instance does the combined silica/alumina molecular ratio fall below 1·56, while the range is from 1·56 to 1·70. The corresponding ratios for samples examined by Bruce (1) varied from 1·0 to 2·6. Pendleton (9) in a paper on " The Use of the Term Laterite " has made out a good case for the restriction of

the term to the material found in tropical countries, corresponding to that described by Buchanan and Oldham. In this sense of the term, local " cabook " may rightly be described as laterite. Pendleton deprecates the use of chemical criteria alone in defining laterite. While there is much to be said for his viewpoint, it cannot be doubted that the silica/alumina molecular ratio of the clay complex is a useful index for classifying soils on a broad basis.

The Lateritic (Cabooky) Heavy Loam.

Location	Ambepussa
Elevation	About sea level
Climate	Rainfall 117 in. ; temperature 81°F.
Geological origin	Charnockite
Mode of formation	Residual
Topography	Undulating ; sample taken from a low hillock
Drainage	Free
Vegetation	Coconuts and garden crops

Profile

A 0–10 in.	Grey-brown, heavy loam with small proportion of ferruginous gravel ; compact but friable ; conglomerate to small clod ; root growth good
B 10–30 in.	Reddish-brown, heavy loam with high proportion of red hydrated ironstone nodules giving horizon mottled appearance ; hard and compact ; conglomerate to irregular clod ; root growth poor
C 30–60 in.	Yellowish-red " laterite " with characteristic pale yellow and red mottlings ; vermicular ; very hard and compact ; roots absent

TABLE II.

The Lateritic (Cabooky) Heavy Loam, Ambepussa

	A Per cent.	B Per cent.	C Per cent.
Mechanical Analysis			
Stones and gravel	10·20	21·75	16·62
Coarse sand	30·6	25·4	19·8
Fine sand	13·6	9·4	13·2
Silt	7·8	5·5	4·9
Clay	43·2	55·0	57·7
Loss by solution	1·8	1·2	0·5
Moisture	3·0	3·5	3·9
Texture index number	39·7	50·1	52·4
Soil type	Heavy loam	Gravelly clay loam	Gravelly clay loam
Chemical Analysis			
Loss on ignition	10·91	11·44	10·55
Combined water	7·78	9·83	9·72
Organic matter	3·13	1·61	0·83
Carbon	1·82	0·937	0·483
Nitrogen	0·158	0·099	0·065
Carbon/nitrogen ratio	11·53	9·47	6·62
Reaction (pH)	6·1	5·6	5·1
Total exchangeable bases (m.e. per 100 gm. soil)	3·15	1·76	0·50

TABLE II.—*contd.*

	A	B	C
	Per cent.	Per cent.	Per cent.
Exchangeable calcium (m.e. per 100 gm. soil)	2·25	1·24	0·26
Base exchange capacity	10·14	10·74	—
Readily available phosphoric acid (mgm. per 100 gm. soil)	0·86	0·53	0·49
Clay Analysis			
Loss on ignition	23·76	19·75	17·59
Silica (SiO_2)	42·08	43·22	42·42
Sesquioxides (R_2O_3)	54·30	53·05	55·05
Alumina (Al_2O_3)	44·72	43·26	46·09
Iron oxides (Fe_2O_3)	9·58	9·79	8·96
SiO_2/Al_2O_3 (molecular)	1·59	1·69	1·56
SiO_2/R_2O_3 (molecular)	1·40	1·47	1·39
Soil type	Lateritic	Lateritic	Lateritic

An examination of the analytical data of a lateritic (*cabooky*) loam profile (Plate III.) reveals that its A, B, and C horizons are heavy loams containing variable proportions of ferruginous concretions. The texture becomes heavier with depth. The nitrogen and organic matter contents are fairly high in the A, fair in the B, and low in the C horizons. The soils of all horizons are acid in reaction, but the acidity increases with depth. The replaceable base contents are low in the top soil, and fall to a very low level in the C horizon. The base exchange capacity of these soils is fairly high, *viz.*, about 10 mgm. equivalents per 100 gm. of soil. The readily available phosphoric acid content is low in all horizons and falls with depth. On the basis of the silica alumina molecular ratios, the soils of even the B and C horizons are of the lateritic type, though in morphological characteristics they are typical laterites.

SOIL CONCRETIONS

(For Table III. see page 73)

The analysis of seven samples of soil concretions or pisolites (*perdigon* as they are known in Cuba) from different parts of the Island show, as to be expected, a great variation in the composition of these materials. The Ambepussa sample is less ferruginous than that from a soil associated with dolomitic limestone at Nalanda. The highest content of alumina is found in the Welimada dry *patana* sample. The concretions from Jaffna are almost entirely composed of limestone. The Hambantota pisolites (peastones) contain as much as 10 per cent. of titanium oxide, while the Peradeniya samples have no less than 13 per cent. manganese dioxide. The Sigiriya dry zone sample is similar to that from Ambepussa, but is more siliceous. The composition of the concretions is largely affected by the nature of the soils from which they were derived. Bennett and Allison (10) and Prescott (11) furnish data in confirmation.

PLATE III.---PROFILE OF A LATERITIC (CABOOKY) LOAM.

TABLE III.

Analyses of Soil Concretions

Place	Jaffna	Welimada	Ambepussa	Nalanda	Peradeniya	Hambantota	Sigiriya
Colour	Mottled yellowish and reddish brown	Dark brown and black	Reddish brown	Reddish brown	Black	Blackish brown	Reddish brown
Consistency	Fairly soft	Fairly hard	Hard	Very hard	Soft	Medium soft	Hard
Shape	Irregular	Round to irregular	Irregular	Irregular	Round	Round	Irregular
Rock from which material is probably derived	Miocene limestone	Khondalite with Charnockite intrusion	Charnockite	Gneiss associated with dolomitic limestone	Material found in pockets of alluvial loam	Intermediate gneiss	Biotite gneiss
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silica (SiO_2)	6·07	29·74	31·04	18·74	26·06	49·82	38·48
Alumina (Al_2O_3)	0·17	29·12	23·15	20·22	14·15	2·70	18·92
Iron oxide (Fe_2O_3)	4·38	21·73	33·86	50·58	20·71	28·87	35·45
Titanium oxide (TiO_2)	—	1·98	2·45	4·00	6·30	9·80	3·50
Manganese dioxide (MnO_2)	—	2·31	0·14	Trace	13·14	1·13	0·52
Magnesium oxide (MgO)	—	2·10	—	1·74	—	—	—
Calcium oxide (CaO)	49·13	—	—	Trace	—	—	—

TABLE IV.

Analyses of Clays

	1. "Kirimetti" from Batapola Per cent.	2. "Sudukirimetti" from Metiyagoda off Ambalangoda Per cent.	3. Peradeniya Per cent.	4. Borales-gamuwa Per cent.	China clay Kaolin (Thorpe) Per Cent.
Loss on ignition	16·85	14·34	13·24	17·85	11–14
Silica (SiO_2)	42·68	47·02	44·03	38·38	45–60
Sesquioxides (R_2O_3)	39·95	36·17	42·64	44·40	—
Alumina (Al_2O_3)	34·51	34·95	41·78	42·56	33–40
Iron oxide (Fe_2O_3)	3·68	1·21	0·87	1·84	—
Titanium oxide (TiO_2)	1·76	Nil	Nil	—	—
Silica/alumina (molecular)	2·09	2·28	1·78	1·53	2·0
Colour	Creamy grey	White	Pale cream	White	—

LOCAL CLAYS

Table IV. above shows the variation in composition of four types of local clays. The Ambalangoda clay approaches China clay nearest in composition and appears to be suitable for the manufacture of good quality China.

SUMMARY

The analysis of nine typical samples of laterite (*cabook*) obtained from different depths of three cabook quarries locally, shows that there are wide variations in composition between the samples. But in all instances, while the iron oxide contents decrease with increasing depth of sampling, the alumina contents increase. On the basis of their silica/alumina ratios, none of the samples would be classified as laterite. The restriction of the term to materials which correspond in morphological and physical characteristics to Buchanan's laterite, as advocated by Pendleton, would avoid much confusion. The morphological and analytical characteristics of a "lateritic" heavy loam are described.

The composition of seven samples of soil concretions or pisolites (known as *perdigon* in Cuba) is very variable and dependent on the nature of the rocks from which the pisolites were derived.

Analytical data in respect of four samples of local clays indicate that some of these are of suitable quality for ceramic purposes.

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PERIODICITY OF NITRIFICATION

PART III. COCONUT AREA

ALEXANDER BRUCE, B.Sc., F.I.C.

GENERAL

COCONUT palms belong to the Monocotyledons while Tea and Rubber previously dealt with in parts I. and II. belong to the Dicotyledons. The methods of absorption of soil nutrients by these plants is the same, via the roots.

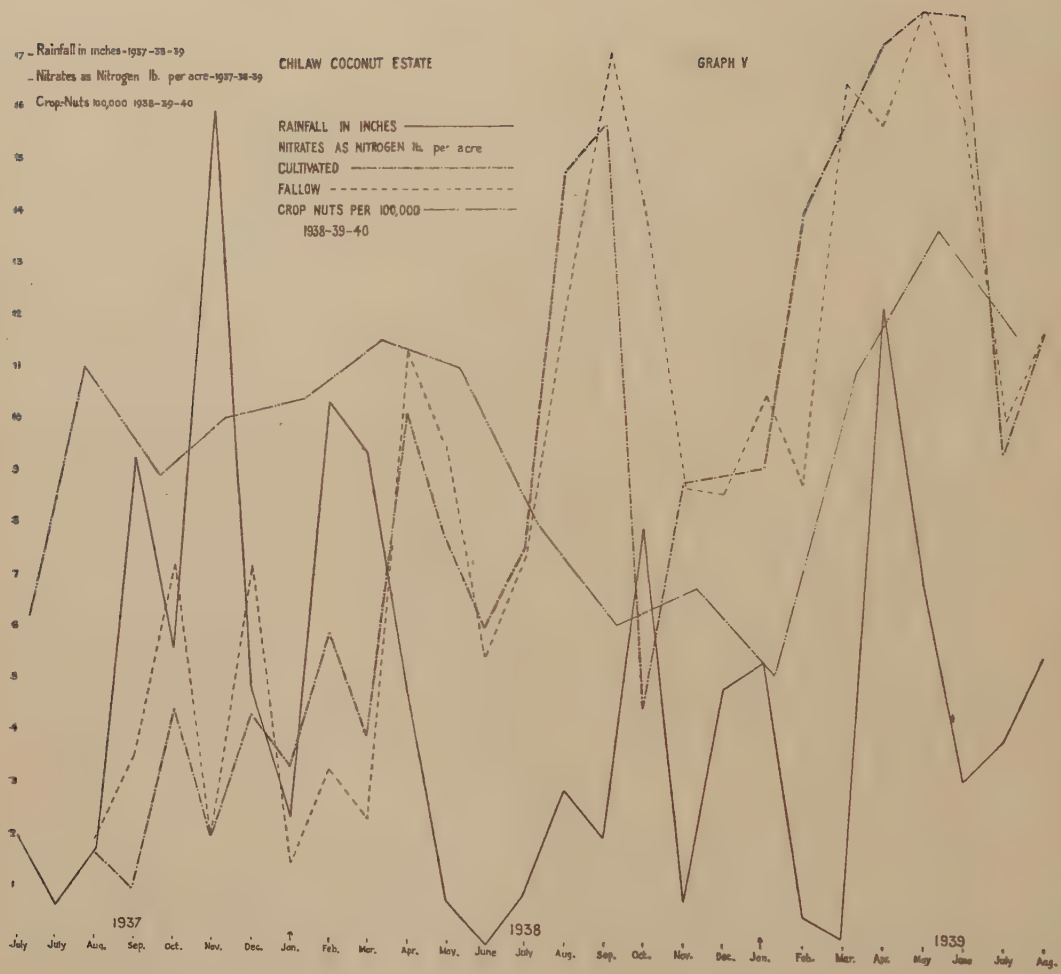
Coconuts shed their leaves throughout the year but absorb most of the cell contents into the main body of the palm, before being severed by the leaf callus. The fallen leaves do not add materially to the nutrients of the soil. Green manure—leguminous crops—are sometimes grown between the rows of palms. Light ploughing and harrowing take place but this is not universal. Coconut husk is occasionally buried in shallow pits with soil between the rows of palms or between four palms. Leaves (pinnae) are sometimes added to these pits, but they are more often burned and the residual ash used as a fertilizer to the palms.

Artificial manure is applied on the best cultivated estates. The continued use of manure gives good results ; spasmodic manuring does not give satisfactory results. Peasants grow grass between the palms and graze cattle tied to the trunks, as a method of fertilizing the palms.

DATA

An estate in the Chilaw District was chosen for the investigation, as the estate is situated in a typical coconut area. The soil in this area is sandy. Coarse sand predominates, 30 per cent. passes the 60-mesh sieve (0·5 mm.): silts and clay are poorly represented. Plant-food is poor in the soil mass.

Rainfall is about 65 inches per annum. Intensities of rainfall over 1 in. are high amounting to 70–80 per cent. A recorded total high rainfall does not mean an even distribution. Such intensities are damaging to the flowers as they are dashed by the high rains. The mechanical state of the coarse sand does not permit the retention of much moisture (20–25 per cent. being an average) but generally the sands are of good depth. From these good draining qualities aeration naturally follows.


Rainfall in inches-1937-38-39
Nitrates as Nitrogen lb. per acre-1937-38-39
Crop-Nuts 100,000 1938-39-40
CHILAW COCONUT ESTATE
GRAPH V
RAINFALL IN INCHES
NITRATES AS NITROGEN lb. per acre
CULTIVATED
FALLOW
CROP NUTS PER 100,000
1938-39-40
17
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July
Aug.

The reaction is about 6·6 (p.H.). Carbon is about one half per cent. and the nitrogen a tenth of that. In the manured area the amount of nitrogen is about 442 lb. per acre. In the fallow area the nitrogen amounts to 537 lb. per acre. This greater amount of nitrogen (95 lb. per acre over the cultivated area) gives the fallow area a greater base for the production of nitrates, especially as there is no competition for the nitrates by coconut roots. From the nitrification figures with an average of 8·9 lb. per acre nitrogen as nitrates, about 2 per cent. of the total soil nitrogen plus manure is nitrified on the manured area, while on the fallow area with 9·2 lb. per acre nitrogen as nitrates, 1·3 per cent. of the total soil nitrogen is nitrified. Nitrates found are residual nitrates. During a third of the initial results nitrites were present but they have been eliminated now.

The carbon:nitrogen on the manured area is 13·3; on the fallow area 12.8.

TABLE V.

Chilaw Estate

	Rainfall				Nitrates as Nitrogen		Nitrites	
	Intensities							
Month	Inches	Days	Per Cent.	Crop	Manured	Unmanured fallow	Manured	Unmanured Fallow
1937				1938				
August	1·72	—	—	1101973	1·6	1·9	Trace	Trace
September	9·22	4	100	895848	1·0	3·5	Nil	Trace
October	5·59	—	—		4·4	7·2	Present	Trace present
November	15·85	5	51	1007840	2·0	2·0	Trace	Trace
December	4·82	1	80		4·4	7·2	Nil	Nil
1938				*1939*				
January	2·33	—	—	1043015	3·4	1·5	Trace	Present
February	10·34	4	73		5·9	3·3	Present	Present
March	9·30	3	36	1151846	3·9	2·4	Fair	Trace
April	4·79	—	—		10·2	11·3	Nil	Nil
May	0·8	—	—	1097287	7·8	9·4	Nil	Nil
June	—	—	—		6·0	5·5	Nil	Nil
July	0·88	—	—	779712	7·5	7·5	Nil	Nil
August	2·95	1	50		14·7	12·1	Nil	Nil
September	2·01	—	—	609588	15·6	17·0	Nil	Nil
October	7·98	2	75		4·5	14·1	Nil	Nil
November	0·81	—	—	677618	8·8	8·8	Nil	Nil
December	4·89	2	66		8·9	8·6	Nil	Nil
1939				*1940*				
January	5·39	2	62	524085	9·1	10·5	Nil	Nil
February	0·60	—	—		13·9	8·8	Nil	Nil
March	0·18	—	—	1089046	15·6	16·4	Nil	Nil
April	12·09	4	71		17·2	15·6	Nil	Nil
May	6·79	2	78	1364561	18·0	18·7	Nil	Nil
June	3·16	—	—		17·8	15·7	Nil	Nil
July	3·96	—	—	1163884	9·4	10·0	Nil	Nil
August	5·53	1	82		11·7	11·7	Nil	Nil

Graph V.—(see page opposite)—The high rains of September and November, 1937, reduced nitrates in these months, owing to the free nature of the sands. The high rains of February and March, 1938, reduced nitrates in March. There was a large

increase in nitrates in April with lower rainfall. With low rains in May-September there were increase of nitrates in August and September. November usually a month of heavy rainfall was poor in rains. The nitrates kept steadily up till the end of the period in spite of high rains in April, 1939. February and March, 1939, were exceptionally dry months.

Taking the graph as a whole the large nitrate production period is during November, 1938, to August, 1939, a period of 10 months and at the finish of the graph there was no tendency to a downward drop. The period before that was from April, 1938, until October, 1938, a period of 7 months. The period before that was from June, 1937, to March, 1938, a period of 10 months, at a lesser concentration.

The graph shows there is better staying power in nitrates during 1938–1939 than there was in 1937 and early 1938, but it should be noted that during 1938–1939 rainfall was much less than during 1937–1938. During November, 1939, there was no high seasonal rain and the May, June, July, 1938, rains were weak.

From the rainfalls of the last five years, 1935–1939, May, September, October, and November are the wettest months, chiefly November, and it is after these wet periods that manuring would be most profitable, say late November and early December and again in late May and early June. Manuring twice a year is always recommended as there are two wet and dry seasons during the book-year.

It takes a year to elaborate a coconut from flower to mature nut, so rainfall and supply of nutrients during that period is important. In order to determine effects of rainfall, &c., on crop, conditions of the previous year should be known.

Coconut palms develop nuts all the year round in order to fulfil the function of reproduction of their species. The vegetative process is in continual production in order to enable the palm to perform its main function. There is no resting period for leaf or fruit production ; it is continual elaboration for 70–80 years of the raw products in soil and air. Soil nutrients must be present for the elaborate searching rooting system of the coconut palm or else the fruit crop suffers.

The fruit of the coconut palm, or the essential part, the kernel, is removed from the cultivated area and steps should be taken to replenish plant-food removed and make up the soil loss by artificial means.

CROP—RAINFALL—NITRATES

As it takes a year to make a coconut the crops of 1938–1939-1940 are taken and plotted against the rainfall and nitrification of 1937–1938–1939.

The heavy rainfall of November, 1937, heavy in intensities and total, probably dashed the blossoms and doomed the chances of the palms, the following year, bearing a heavy crop at that time. The heavy drop in crop from July, 1938, to January, 1940, was due to the low rainfall for 5 months from May-September, 1938, and again in November. Higher nitrification could not counteract this drought. The heavy increase in crop from February-August, 1939, coincides with better rainfall in April-May and a long period of high nitrification extending from November-August, 1939.

Rainfall is the determining factor in crop. Manuring takes place in the autumn between alternate squares of coconut palms at the rate of 15 lb. per application containing 20 lb. nitrogen, 50 lb. phosphoric acid, and 25 lb. potash. There is also a spring dressing of 6 lb. on every square of a more soluble mixture containing about the same plant-food.

SUMMARY

TABLE VI.

District.	Elevation	Rainfall	Nitrogen Total lb. per Acre		Average monthly Nitrogen as Nitrate lb. per Acre	
			Cultivated	Uncultivated Fallow	Cultivated	Uncultivated Fallow
	Feet.	Inches.				
Dimbulla	5,300	90	6,345	5,489	105	75
					1·6%*	1·4%*
Badulla	3,500	77	2,400	1,500	73	57
					3·1%*	3·6%*
Kelani Valley No. 1	Low	163	3,260	2,865	29	20
					0·9%*	0·7%*
Kelani Valley No. 2	Low	180	3,285	3,117	28·6	22
					0·8%*	0·7%*
Chilaw	Low	65	442	537	8·9	9·2
					2%*	1·7%*

* Percentages of the gross nitrogen.

It is interesting to consider nitrification under different conditions of elevation, rainfall and soil conditions.

Nitrates found on a cultivated area are residual from plant absorption from nitrate prepared from soil nitrogen and manures. A fallow area has not the same competition from plant absorption and is consequently higher in nitrates on some occasions. In the rubber area, this was divided into manured and unmanured — not fallow. Both areas had this absorption of nitrates from full growing rubber trees.

Reference to Table VI.—

Dimbulla and Badulla are tea areas.

No. 1 and No. 2 Kelani Valley are rubber estates.

A Chilaw coconut estate on a sandy soil.

Dimbulla District.—The richest in nitrogen in the series nitrifies to 1·6 per cent. in the cultivated area and 1·4 per cent. in the fallow area. This is in a cool climate.

Badulla District.—Soil containing about a third of the total nitrogen of Dimbulla soil at a lower elevation and warmer climate, nitrifies to the extent of 3·1 per cent. in the cultivated area and 3·6 per cent. on the fallow area. This is about twice the nitrification of the Dimbulla area.

No. 1 Kelani Valley is at a low elevation and with heavy rainfall about double that experienced on Dimbulla and Badulla tea estates resulting in a hot steamy climate. No. 1 Kelani Valley estate soil is richer in nitrogen than Badulla tea area and nitrifies to the extent of 0·9 per cent. in the cultivated area and 0·7 per cent. on the unmanured area. A broad casting of 1 cwt. of burnt lime accelerates the nitrification.

No. 2 Kelani Valley estate soil nitrifies to the extent of 0·7 per cent. on the unmanured area and 1·2 per cent on the manured area. The latter high result is entirely due to one month giving a very high nitrification after manuring with nitrate of soda, in dry weather. Eliminating that month, nitrification average per month is 28·6 lb. per acre=0·8 per cent. on the total nitrogen.

The soil of the Chilaw coconut area which is a typical coconut sand, with 65 in. rainfall, classified as in the drier area, has a nitrification of 2 per cent. on the cultivated land and 1·7 per cent. on the fallow.

The outstanding feature of these results is the high percentage nitrification on Badulla tea area soil and the low nitrification on the rubber area soil. The Chilaw coconut sand was the second highest in the series next to Badulla and more than Dimbulla.

Authorities not getting the desired results on rubber leaf and latex added up to 6 cwt. of ammonium sulphate equal to 120 lb. of nitrogen per acre in one application, the bulk of which was lost to the proprietors as unabsorbable. As there was not sufficient organic matter or carbon in the soil to rectify the carbon : nitrogen on the balance of nitrogen, the unanchored nitrogen went to waste. Similarly in the tea area up to 200 lb. of nitrogen per acre were added in one application, unabsorbable, and was largely lost to the proprietors. These applications were recommended by advisers to the estates.

If the monthly average production of nitrogen as nitrates is multiplied by twelve the yearly nitrate production is obtained. If that is compared with the total nitrogen the life of the estate, based on the nitrogen, may be predicted presuming that all the nitrates formed were absorbed by the plants or taken from the estate by other means, such as seepage.

TABLE VII.

District	Monthly Nitrification lb. per acre	Yearly Nitrification lb. per acre	Gross Nitrogen	Life Years
Dimbulla	105	1,260	6345–6300 (=1260×5)	5
Badulla	73	876	2400–2628 (= 876×3)	3
Kelani Valley No. 1	29	348	3260–3480 (= 348×10)	10
Kelani Valley No. 2	29	348	3585–3480 (= 348×10)	10
Chilaw	9	108	442–432 (= 108×4)	4

As these estates are much older than their predicted nitrogen life, the conclusion to come to is that nitrate production is not a wasting asset on the estates owing to the nitrates being immobilized by proteinization and retained in the soil until nitrification conditions recur. Such conditions only occur on properly cultivated estates.

It may seem strange that, considering several thousand pounds of nitrogen are found in each acre of land, it is necessary to add artificial manure to obtain crops. The explanation is that the nitrogen on an acre of soil is distributed in a more or less inert condition over the whole acreage while the roots of the plants only occupy a small portion of the land. Application of manures is as near the feeding roots as is practicable and is accompanied by green manure prunings which stimulates bacterial action and absorption of nutrients by the plant.

The composition of all crops is known so that the plant food removed by crops from the land can be replaced. Tea and coconuts remove large quantities of plant food from the land while rubber removes practically nothing compared to these. Rubber is produced mostly from the carbon dioxide of the air; yet rubber land has been highly fertilized in an attempt to stimulate the trees to give more rubber.

All details were collected by Messrs. A. Baur & Co., Ltd., and to them and the Superintendent of the estates thanks are rendered. Messrs. A. J. Cameron and P. J. Edward carried out the analytical part and to them thanks are given.

Laboratory,
Green path, Colpetty.

AN INVESTIGATION OF METHODS OF SEPARATING ECHINOCHLOA SEEDS FROM SEED PADDY

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THE four species of *Echinochloa* occurring in Ceylon, *viz.*: *E. colona*, *E. frumentacea*, *E. crus-galli* and *E. stagnina*, better known locally under the Sinhalese names of *wel marukku*, *maruk*, *goma-tana* and *gogera-welu* and the Tamil names *kolichudan* and *kuthirai vali*, constitute some of the most damaging of paddy field weeds. A detailed description of the four species has been given by Paul and Senaratna (1941). These species (which in this article are included collectively under the name *maruk*) seed freely. Moreover, new shoots develop on the basal parts of old, decumbent stems, root on coming in contact with the soil or with water, and become detached from the parent stems by the decay of the internodes. These shoots soon produce earheads, even before their separation from the parent stems. In this way the *maruk* plant propagates rapidly. The seed may either be shed in the field or it may become mixed with the seed paddy in the harvesting and threshing operations.

If the freedom of seed paddy from admixture with *maruk* seed is not ensured continued reinfestation of the fields will occur at sowing time. Seed paddy derived from *maruk* infested fields will contain a proportion of *maruk* seed varying with the severity of the infestation in the fields at harvest time. It is desirable that such seed, if used for sowing, should be completely disinfested. The results of experiments designed to investigate methods of ridding seed paddy from contaminating *maruk* seed, are presented in this contribution. The efficacy of careful winnowing and of floating infested seed in water was investigated.

EXPERIMENTAL MATERIAL AND METHODS

Samples of seed paddy (*pachchaiperumal* and *vellai illankalayan*) contaminated with seed of the four species of *maruk* found in Ceylon, *Echinochloa colona*, *E. frumentacea*, *E. crus-galli* and *E. stagnina* were used. The samples were obtained from the Paddy Stations at Tabbowa and Nalanda.

A hand winnow (S. *kulla*, T. *kullam* or *sulaku*) of the type commonly used in villages, was employed in the winnowing tests. The winnowing was carried out with elaborate care, small quantities of seed being handled at each operation.

The immersion method aimed at exploiting the lower specific gravity of *maruk* seed. The contaminated seed was placed in a bucket, covered with approximately its own volume of water, and stirred vigorously. A proportion of the *maruk* seed floated to the surface and was decanted off. The immersion in water and subsequent decanting may be repeated till no more *maruk* seeds float to the surface.

Estimates of the efficacy of the treatments were provided by counts of the numbers of *maruk* seeds in two ounce samples of infested seed subjected to the various treatments.

RESULTS

The results obtained in these treatments are presented in Table I. The data form part of a binomial distribution and must accordingly undergo transformation to an inverse sine scale ($\theta = \sin^{-1}\sqrt{p}$) before they can be validly subjected to an analysis of variance (Cochran, 1938). The analysis of variance of the transformed data for treatments i., ii., iii., v., and vii., is presented in Table 2. The value of F for treatments exceeds the 5 per cent. point and is hence indicative of significant effects. A summary of the means transformed back into the original scale is given at the foot of the table.

TABLE 1.

Percentages of Echinochloa Seeds Removed by Various Treatments.

Sample	Treatment I. Winnowed (pachchai-perumal—Nalanda)	Treatment II. Decanted once (pachchai-perumal—Nalanda)	Treatment III. Decanted twice (pachchai-perumal—Nalanda)	Treatment IV. Decanted thrice (pachchai-perumal—Nalanda)	Treatment V. Decanted once (vellai-illankalayan—Tabbowa,	Treatment VI. Decanted twice (vellai-illankalayan—Tabbowa,	Treatment VII. Decanted once (vellai-illankalayan—Nalanda,	Treatment VIII. Decanted twice (vellai-illankalayan—Nalanda)
1	98 per cent.	81 per cent.	94 per cent.	100 per cent.	97 per cent.	100 per cent.	71 per cent.	100 per cent.
2	98	87	100	100	83	97	100	100
3	95	88	94	100	76	100	75	100
4	97	85	99	100	93	100	100	100
5	99	91	99	100	88	100	50	100
6	93	86	100	100	89	100	100	100
7	98	89	100	100	86	100	80	100
8	98	91	99	100	94	100	100	100
9	95	85	96	100	100	100	100	100
10	99	78	91	100	100	100	100	100

TABLE 2.

Analysis of Variance of Transformed Data

($\theta = \sin^{-1}\sqrt{p}$)

	DF	SS	MS	VR	Five per cent. point	One per cent.
Treatments	4	1242·16	310·54	3·22	<2·61	>3·65
Error	45	4336·84	96·37			
	49	5579.00				

	TREATMENT MEANS					STANDARD ERROR
	I.	II.	III.	V.	VII.	
Degrees ($\theta = \sin^{-1}\sqrt{p}$)	80·5	68·3	82·6	74·5	76·6	±3·105
Percentages	97·3	86·3	98·3	92·8	94·6	

The degree of infestation in the original material varied widely, and the numbers of *maruk* seeds per ounce of the original material are given below :

MATERIAL USED.	NO. OF MARUK SEEDS PER OZ.
Treatment i.	39
Treatments ii., iii. and iv.	59
Treatments v. and vi.	15
Treatments vii. and viii.	5

DISCUSSION

The measure of control achieved by careful winnowing was very high—in one instance it was significantly greater than that obtained by a single decanting—but it was never complete. Besides, the method is much too laborious and slow to be of use in *Echinochloa* control.

A single immersion and decanting removed a high percentage of *maruk* seeds. Removal became, of course, progressively more complete with successive immersions. If the infestation is mild, a second immersion is all that is necessary. With severe infestations, a third immersion may be needed. After the immersion treatment, the seed may be dried immediately in the sun for about 4 hours and stored for use later or it may be germinated and sown at once. It was found that the seed subject to the immersion treatment gave a germination percentage of 100 when tested a month later. This is due to the fact that in the immersion process all the light seed floats to the surface with the *maruk* seed and is removed with decanting.

The results presented in this contribution are derived from experiments with relatively small quantities of infested seed.

The immersion treatment has, however, been practised with three decantings, using quantities up to 2 bushels at a time and 100 per cent. clean seed paddy obtained. Larger quantities may be handled at a time, provided suitable receptacles for immersion are available.

These experiments have not explored all the theoretically possible methods of purifying seed paddy. If *maruk* seeds are considerably more sensitive to heat than paddy, temperatures lethal to maruk seeds but not to paddy may be employed in *maruk* control.

The maximum diameter of *maruk* seeds and the minimum effective diameter of paddy seeds (*vellai illankalayan* and *pachchaiperumal* varieties) are 2·85 mm. and 2·75 mm. respectively; there is, accordingly, little promise of successful exploitation of sieving as a method of *Echinochloa* control.

The method of seed treatment employed should, of course, be supplemented by the use of cultural methods in the field. The cultural methods available to the grower are briefly reviewed here.

In the control of *maruk* in paddy fields, it is essential that the weeds should be removed as soon as they are detected in the field. It is difficult, however, to distinguish *maruk* from standing paddy before the weed commences flowering, without examination of individual plants, but as it flowers much earlier than paddy, it can be uprooted without great disturbance of the paddy plants during the early stages of growth of the crop. Every *maruk* plant should be uprooted before the ear heads mature in order to prevent the seed being shed in the field, and care should be taken, especially in the case of *E. stagnina* which produces long creeping stems as the plants become older, that no fragments of stems containing one or more nodes which are likely to develop new shoots are left behind. The uprooted plants should not be heaped along the bunds of the fields as they are liable to continue growing and as there is the danger that the seeds may fall into the fields. They should either be thrown into compost heaps where there is a certainty of the composting process being well carried out and the seeds being destroyed by the heat developed in the heaps, or they should be buried in pits.

The infested field should be ploughed soon after the harvest of the paddy with a mould-board plough. All stools and fragments of stems which are difficult to eradicate by hand will thus become buried in the soil and no regrowth from the stems will take place, provided in the process of ploughing, these are buried to a depth of not less than three inches.

When the preparatory tillage operations for the next season are due to commence, the fields should on this occasion be cross ploughed, but if in the meantime, *maruk* plants are seen in flower, they should be immediately uprooted by hand. A fortnight later, a third ploughing should be given, followed by harrowing with the Burmese harrow after ten days. A second harrowing should be done about ten days later and the fields then levelled for sowing or transplanting the crop. If a single late maturing crop is only grown for the year then the fields should be periodically harrowed so as to destroy any *maruk* seedlings which develop from seed which has previously been shed in the field.

SUMMARY

1. Methods of freeing seed paddy from contaminating *maruk* seed have been investigated.

2. Winnowing, though providing a high degree of control, is a slow and laborious operation.

3. A series of three immersions in water and subsequent decanting provides complete control and is recommended.

4. Cultural methods of eradicating *maruk* from infested fields during the interval between harvesting and sowing or transplanting the subsequent paddy crop are briefly reviewed.

5. Every *maruk* plant should be uprooted from the standing paddy as soon as it is recognized in the flowering stage as otherwise the ear heads mature and the seeds are shed in the field and germinate or become mixed with the seed paddy during harvesting.

ACKNOWLEDGEMENT

We gratefully thank Mr. T. V. Thamotheram, Agricultural Instructor, Puttalam, and Mr. P. A. Gooneratne, Agricultural Instructor, Nalanda, for their assistance.

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[In addition to the methods of freeing seed paddy from the seeds of *maruk* which are discussed in the above article, trials are being made with sieves of various types the results of which will be published later. *Ed. T. A.*]

DEPARTMENTAL NOTES

LAYING RECORDS OF PULLETS HATCHED FROM EGGS IMPORTED BY AIR MAIL

A short note was published in *The Tropical Agriculturist* for July, 1940, on the performance of a batch of 8 Rhode Island Red pullets which had been hatched from eggs sent from England by air mail. By the end of December, 1940, complete records for 12 months laying were available for each of the birds except No. 17 which had started to lay in February, much later than the others.

The complete records are published on account of the high average production of these 8 birds, the unusually high individual record of hen No. 19 and the fact that the 8 pullets have completed a year's laying without any mortality or illness.

Hen No. 19 is worthy of special mention because in the 12 months from January 1 to December 31, she laid 304 eggs, a very high record for Ceylon. This hen is of medium size weighing 5 lb. 2 oz., handles very well, has good head points, and is not loosely feathered; indeed her plumage is tighter and closer-textured than is typical of the Rhode Island Red breed. From an exhibition point of view her colour is poor being too light in shade. The photograph shows her type. The number of eggs laid by each hen during the period January 1 to December 31, 1940, is as follows :—

No. 19—304 ; No. 23—253 ; No. 17—235 in eleven months ; No. 20—228 ; No. 21—211 ; No. 16—203 ; No. 18—193 ; and No. 22—161 ; giving an average of 223 eggs per hen.

Block by Survey Dept.

RHODE ISLAND RED HEN NO. 19 HATCHED FROM EGG IMPORTED BY AIR MAIL.

CONTROL METHODS FOR PADDY PESTS.

PADDY pests can easily be prevented from causing damage to paddy cultivation if the following simple agricultural practices are observed.

(*a*) All wild grasses and weeds which grow on the bunds, round the borders of paddy areas, along the irrigation and drainage channels, and on the patches of high-land in paddy areas, should be kept cut short throughout the year, especially during periods when the paddy crop is not seeding. If these wild grasses and seeds are allowed to grow tall they serve as feeding and hiding places for large numbers of insect pests which attack the paddy plants when their growth has reached a suitable stage. Cutting this vegetation regularly, either for feeding to cattle or for use in making manure, is the best and most economical way of utilizing it and of reducing the number of insect pests.

(*b*) Special care should be taken to construct and maintain permanent wide-based bunds with well-sloped sides (*i.e.*, not too vertical, and so as to form stable bunds on the tops of which beans, murunga, katurumurunga, and other additional food crops can be grown) of sufficient height to make it possible to flood the plants when they are in the younger stages of growth so that if the pest does appear the fields can be flooded and the pest easily destroyed.

(*c*) Make a careful inspection of your fields after the first six weeks of growth and remove all weeds as these not only choke up the paddy plants but serve to protect the pest from any control action that might be taken to get rid of it.

SELECTED ARTICLES.

PISÉ DE TERRE: A CHEAP METHOD OF ENCLOSING LAND OR FIELDS*

FOR many years, the management of the Government Cattle Farm, Hissar, has been in search of some method of building labourers' quarters, godowns, cowsheds, enclosure walls, &c., cheaper than *pucca* masonry and cheaper and more lasting than *kacha* brick. The solution has now been found in *pisé de terre* (rammed earth).

Sixty-five labourers' quarters of *pisé de terre* are now in course of construction on the farm, but it was not the intention of the author to rush into print until the work ended, and the accounts are finally closed.

At a meeting of the Central Fodder and Grazing Committee of the Imperial Council of Agricultural Research, held in New Delhi on November 21, 1938, the following items were discussed :—

(*a*) The high cost of wire fencing for enclosing grazing lands and experimental areas.

(*b*) The problem of finding suitable plants for " live " cattle-proof hedges, for enclosing fields, pastures, &c.

The reason for the search for " live " hedges is, of course, the necessity for finding some cheap substitute for wire or masonry fences, which are very expensive to erect and maintain.

It was recognized that it might take many years of research to discover plants suitable for the variety of climatic conditions found in this country, and many more years to establish them as " live " hedges.

The author suggested that in the meantime, walls of *pisé de terre* might be used, and was asked to prepare a note regarding the construction of boundary walls of *pisé de terre*, from experience so far gained from this type of construction, now in progress on his farm.

This article should, therefore, only be regarded as a preliminary note to a more elaborate description of *pisé* building in general, which will follow.

The information given herein, however, is sufficient to enable cheap and lasting boundary walls to be constructed by unskilled labour.

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* By W. S. Read, P.V.S., Superintendent, Government Cattle Farm, Hissar, India, in *Agriculture and Live-stock in India*, Vol. IX., Part IV., July, 1939.

Pisé de terre (rammed earth) must on no account be confused with the sun-dried brick, and mud-walling operations, carried on in many parts of this country. Advocates of *pisé de terre* have the greatest difficulty in convincing the uninitiated that this type of construction, is different from, and much stronger and more permanent than sun-dried brick or mud walls. Mud (wet soft earth) has no place in *pise' de terre* practice.

Building construction in *pise' de terre* is no new or modern invention. It has stood the test of time. Pliny mentions it in his "Natural History". The Romans introduced it into France, and buildings of *pise' de terre* have been erected in England, Africa, Australia, New Zealand, Mexico and California, representing a very wide range of climatic variation. Even in India *pise' de terre* is not unknown, as work of this description was carried out at Etah Gaol in 1867–68. Nevertheless although building in *pise' de terre* has been practised for so many centuries in so many widely spread countries, the process is still unknown to the mass of the general public. Moreover, those who have had experience of this cheap and simple method of construction are most enthusiastic regarding its merits. One is, therefore, forced to the conclusion that the only reason for it not being more widely known and practised, is prejudice on the part of the building trade, because it throws open a field for unskilled labour, supervised by very few skilled or semi-skilled artisans. On the work now in progress at Hissar, the only tradesmen employed are two masons on annas ten each *per diem* and one carpenter on annas eight *per diem*. The remainder of the gang are all entirely unskilled labourers.

The whole process of *pise' de terre* building construction can be condensed into a few words. It consists of erecting parallel wooden shutters on the site of the wall to be erected. The distance between these parallel shutters being the width of the wall required. A layer of fine earth (not mud), some four to five inches deep is spread evenly between the shutters. This earth is well rammed with wooden rammers, until they fail to leave an impression upon it. Similar layers of earth are spread and rammed until the top of the shuttering is reached. The shutters are immediately dismantled and set up for the next section. The full height of the wall is reached by placing the shutters on the courses of the wall already completed. Several sets of shutters may be in use at the same time, for as soon as two sections of the first course are finished the second course can be commenced. When two sections of the second course are ready the third course can be commenced and so on. The work thus progresses in a series of steps, which eliminates the necessity for ladders or scaffolding.

DETAILS FOR CONSTRUCTING A PISE' DE TERRE WALL FIFTEEN INCHES THICK AND SIX FEET HIGH INCLUSIVE OF SIX INCHES AS FOUNDATION.

I.—Materials Required.

(*a*) *Shuttering.*—There are several types of shuttering in vogue, designed to suit individual fancy and the standard of the labour to be employed. There is a big field for research in shutter design for *pise' de terre* work.

For the work at Hissar, shutters of the utmost simplicity and cheapness were evolved, devoid of all complications, such as special moulds for corners or for joining walls at right angles. External braces and scaffodling were also eliminated. In this case, the length of the pairs of shutters was determined by the fact that blocks of quarters with rooms 10 ft. by 10 ft. were to be built. Shutters 7 ft. 3 in. in length were made to allow of each course of each 10 ft. wall being built in two sections, with allowances for overlap at the joint and for interlocking with adjoining walls. For an ordinary straightforward boundary wall, shutters 9 ft. in length can be used. Longer than this might be found heavy and unwieldy in operation.

To commence operations, construct an even number of shutters from any hard, dry, well-seasoned wood, each 9 ft. by 2 ft. by $1\frac{1}{4}$ in., strengthened with four battens each 2 ft. by 6 in. by 1 in., rivetted on to one side of the shutter only (Fig. 1). The inner face of the plank to be as smooth as possible, with the heads of all batten rivets filed down flush with the wood. Holes $\frac{3}{4}$ in. in diameter should be bored through the battens and plank, centred exactly 3 in. from the edge of the plank, to take the metal distance rods. Each hole should be protected by metal plates on both the inner and outer faces of the shutter. The inner plate prevents damage to the shutter by the shoulder of the distance rod, and the outer plate protects the batten from damage by the distance rod wing-nut. An iron handle is fixed to each batten to facilitate handling. A strip of 1-in. angle iron is nailed to the inner edges of the shutters to save them from damage by blows from the rammers.

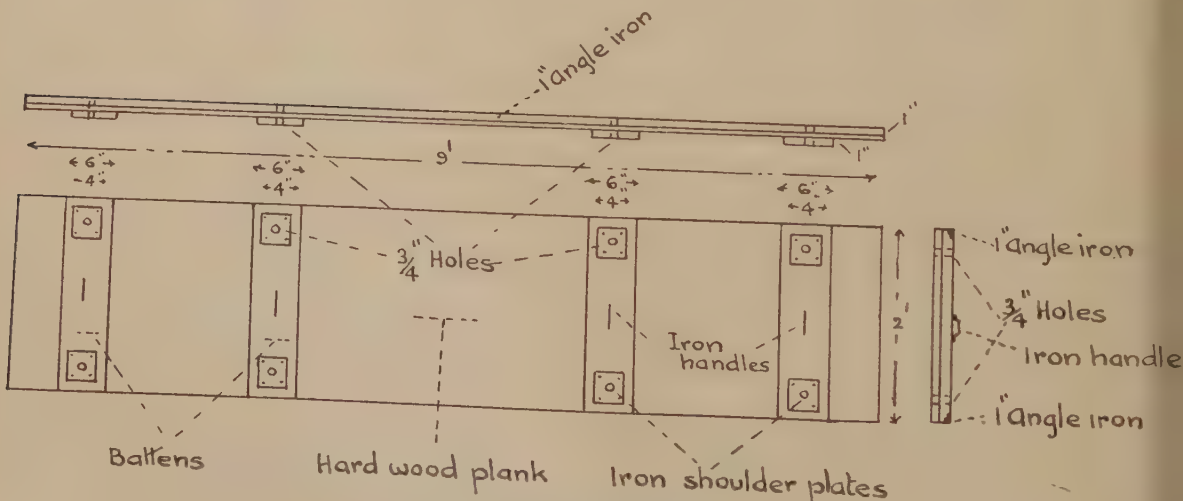

Fig. 1. Side planks

(*b*) *End-planks.*—Several plain "end-planks" (for square corners) will be required, for leaving spaces for gateways through the walls. One or more

"end-planks" (for making a rounded corner) will also be required. Rounded corners are usually made on the outer angles of walls to prevent chipping and damage. The dimensions of these end-planks are given in Fig 2.

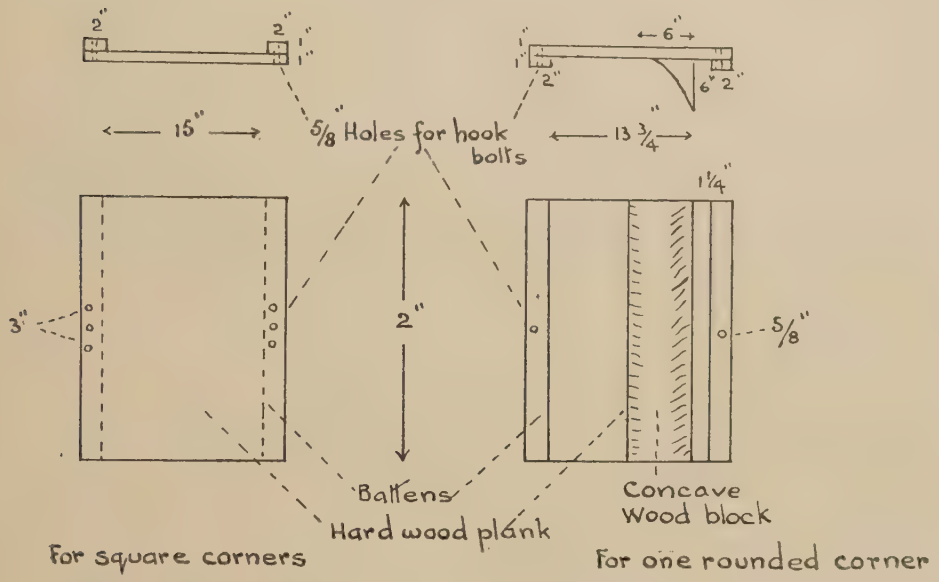

Fig. 2. End-planks

(*c*) *Hook-bolts.*—Each end-plank will require two hook-bolts the dimensions of which are given in Fig. 3. The method of fixing is to place the end-plank in position at the end of a pair of shutters, where a finish off for a gate or doorway is required. Pass the hook-bolts through the holes in the end-plank, and run the nuts on a few turns. Engage the hooks over the edges of the two end battens of the shutters, and tighten up the wing-nuts until the end-plank is securely fixed in position.

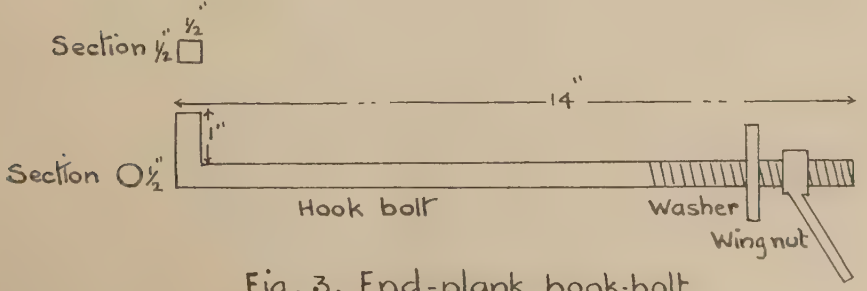

Fig. 3. End-plank hook-bolt

(*d*) *Distance Rods.*—It is quite obvious that to build a good straight wall, the pairs of shutters must be kept exactly parallel. This is achieved by means of " distance rods ". Most writers remark on the difficulty of removing these rods from the wall after the earth ramming is completed. Some workers, in fact, prefer elaborate bracing mechanism out-side the shutters instead of distance rods, because of the difficulty experienced in extracting them, and the damage often done to the wall in the process.

To overcome this difficulty the author evolved the " Taper Distance Rod " illustrated in Fig. 4, which is completely successful. A light tap with a piece of wood on the taper end of the rod loosens it sufficiently to enable it to be withdrawn from the wall without any damage. The " taper " distance rod illustrated has an inner dimension of 15 in., but any size can be made according to the thickness of the wall required. Any blacksmith can prepare these rods, and the iron fittings for the planks. The planks can be built by any village carpenter.

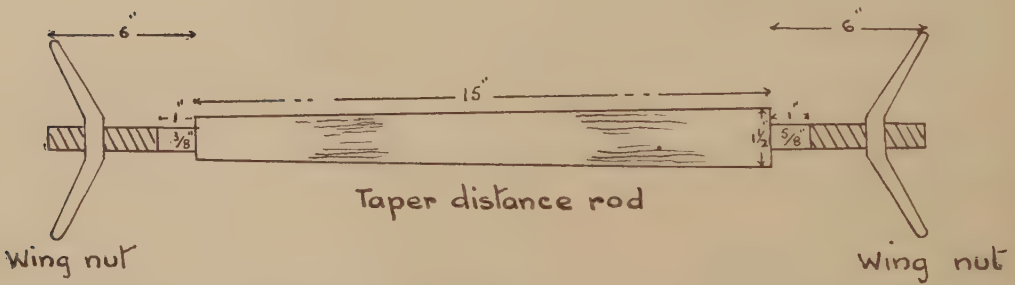

Fig 4.

Eight distance rods should be provided for each pair of shutters, although in actual practice only four are used. The surplus allows of the upper rods being left in the wall when the shutters are removed, so that they can be used as bottom rods when shutters are placed for the next course of the wall. The extra rods also provide a reserve against breakage or damage.

(*e*) *Rammers.*—The dimensions of the rammers used are shown in Fig. 5. They should be made of hard well-seasoned wood, free from knots and cracks. The striking surface should be finished off completely smooth. Each rammer should be fitted with a long bamboo handle. The half-round rammer (B) is used for ramming the earth in corners and along the sides of the shutters, and also adjacent to the distance rods. Two square rammers (A) and one half-round rammer (B) should be provided for each pair of shutters. Two *beldars* to each mould are required for ramming.

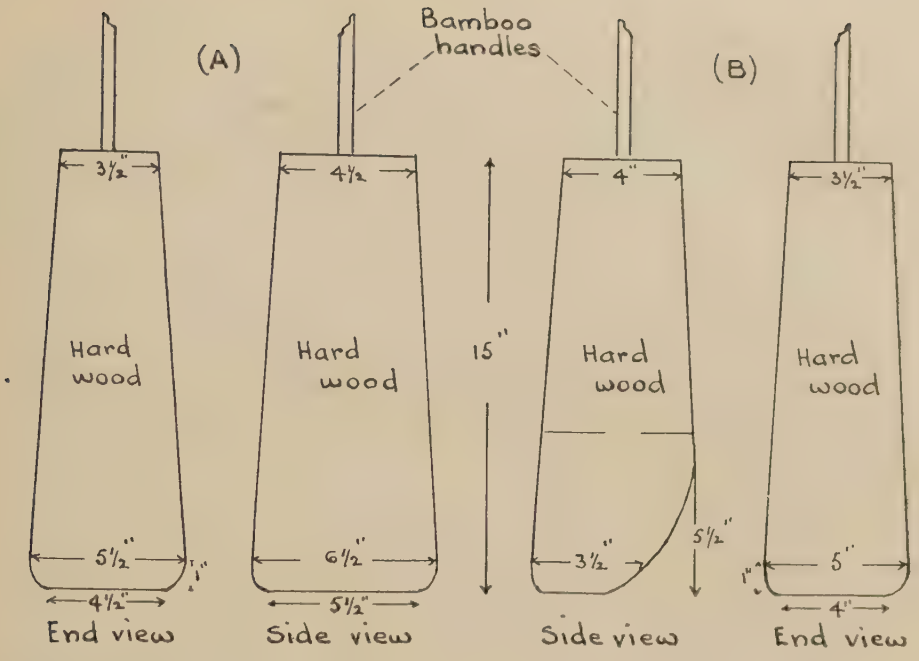

Fig. 5 Rammers

(*f*) *Soil.*—Almost any good arable soil is suitable for *pisé* work. Heavy clays, and light sands should be avoided. Soils can of course be blended, heavy soils with an admixture of sand, and light soils with an admixture of clay. The soil used must be dry, not wet, and the simplest test to prove the soil prepared, is to grip a handful tightly for a few seconds. If on opening the hand it remains compressed in a ball, the moisture content is too high. If it breaks down into dusty particles too rapidly it is too dry. If it cracks and disintegrates slowly it is correct. This test should be applied frequently and regularly throughout the operations.

The soil should be broken down finely, and none of the particles should exceed the size of a walnut. No grass or other vegetable matter should be permitted to remain in the soil. Nor should more soil than the quantity required for the current day's work be prepared at one time. The surface of the area from which the earth is taken should first be removed and placed on one side, to avoid having vegetable matter in the soil to be used. If the soil is excavated to a considerable depth, care should be taken to see that there is no change in the soil formation. If any change is found, the material should be blended to the correct consistency.

II.—Building Operations.

(*a*) *Foundations.*—If desired the foundations for a heavy building may be of *pucca* brick, the top course of which should be of the same width as the wall to be erected, so that the shuttering may be firmly clamped on to the same. For an ordinary enclosure wall, however, a *pucca* foundation is not necessary and in any case adds to the cost.

Dig a trench on the site of the wall to be erected, 2 ft. and 15 in. wide and 6 in. deep. In the centre of the bed of the trench mark off two lines 15 in. apart, running the full length of the trench. Dig out a further 6 in. of earth on each side of these lines, leaving a foundation ridge 6 in. high and 15 in. wide (Plate I., Fig. 1). From the ends of the trench run out similar trenches at right angles until the whole area to be enclosed is surrounded. Gaps should be left in the trench where gateways in the walls are required. Level off the top of the foundation ridge where necessary.

Commencing at one corner of the enclosure, join two shutters together with the four distance pieces, leaving the wing-nuts loose. The distance rods should not be one above the other. Also see that the thick ends of the bottom taper rods are not both in the same side, otherwise the shutters (which now become a mould) will not stand vertically on the foundation ridge. The mould should overlap the second foundation ridge which runs off at right angles. A narrow groove must be cut in this ridge to accommodate the first 15 in. of the inner shutter otherwise the mould will not stand upright. Next tighten up the wing-nuts until the mould has taken a firm grip on the foundation ridge. Use a spirit level and plumb-line to set the mould perfectly upright. At the wall-angle end of the mould, fix the end-plank in position, using one which will provide for a rounded corner on the external angle of the wall. No end-plank is required at the other end of the mould.

Cover the two bottom distance rods which are resting on the foundation ridge with some of the prepared soil. Ram it well, adding more earth as required, until both rods are embedded in blocks of earth. This is extremely important, as if ramming is started all over the mould to commence with, the mould will gradually creep upwards as the ramming continues. If the bottom distance pieces are first covered and rammed well, the mould will remain firmly anchored to the foundation ridge. After the bottom distance rods have been firmly fixed in this way, spread a layer of prepared earth, 4 to 5 inches deep, evenly over the bottom of the mould. Ram this well until the rammers leave no impression on the earth. Pay particular attention to the edges of the shutters and the end-plank by ramming with the half-round rammer. Continue to add four to five inch layers of earth, ramming them as above, until the top of the mould is reached. The rammed earth at the open end of the mould is finished off as a slight slope (Plate IV., Fig. 2) as this makes a better joint than a straight end when the next mould is filled. The shutters can be removed immediately the ramming is finished. The two upper distance rods and the bottom rod nearest the sloped end of the earth block, may be left in the wall for use with succeeding shutters.

Next clamp a mould on to the foundation ridge of the other wall, pressing the ends of the shutters close up to the overlapping portion of the earth block already made. No end planks are necessary in this case. Fill and ram as before. When the mould is removed, two earth blocks at right angles forming the angle of the wall will be in position. A mould can now be set up at each end, overlapping the slopes of the earth blocks, and a third mould can be set up on the blocks already built, to commence the angle of the second course. This

Block by Survey Dept.

FIG. 1.—FOUNDATION RIDGE

Block by Survey Dept.

FIG. 2.—A MOULD ERECTED

Block by Survey Dept.

FIG. 1.—MOULD WITH END-PLANK

Block by Survey Dept.

FIG. 2.—RAMMING

Block by Survey Dept.

FIG. 1.—A MOULD IN POSITION

Block by Survey Dept.

FIG. 2.—MAKING A CORNER

Block by Survey Dept.

FIG. 1.—A *pisé* BLOCK

Block by Survey Dept.

FIG. 2.—SHOWING METHOD OF SLOPING BLOCKS FOR JOINTS

mould should be clamped on to the second earth block which was made, overlapping the end of the first block. A round corner end-plank should be used. Alternate courses should overlap in this manner at the corners, to dovetail them for greater strength. As soon as the shuttering for the first block of the second course is taken down, four moulds can be brought into use simultaneously, and the work will proceed very rapidly.

The holes from which the distance rods are removed should be filled with loose earth tamped well home with a small wooden rod.

The walls should be allowed to dry out for about fifteen days before they are finished off with plaster. Ordinary *lepai* plaster, such as is used for *kacha* walls will do, and a coating of coal tar will render it impervious to the weather.

The most vulnerable part of these walls is the top, which should be well finished off. Driving rain has little effect on the sides of the walls if they are properly plastered, but water percolating through the top of the wall can do a lot of damage.

If desired, the top of the wall can be finished off with a few courses of burnt bricks in line, which should include a drip course.

Should something cheaper be desired, round off the top of the wall with mud and plaster it, giving a final coat of tarcoal if ordinary country plaster is used.

Conclusion.

Walls of this description can be made for about Rs. 1,300 a mile, entirely by unskilled labour, supervised by an ordinary mason to use the plumb line to keep the moulds upright. This estimate includes the cost of maintenance of a pair of bullocks to plough and cart the soil and also cart water to the site. This shows a tremendous saving on Public Works Department estimates for brick walls which work out as follows :—

(*a*) Burnt brick in mud with cement pointing—Rs. 10,560 per mile.

(*b*) Burnt brick in mud, but without cement pointing—Rs. 7,920 per mile.

(*c*) Sun-dried bricks in mud with $7\frac{1}{2}$ in. top course of *pucca* burnt brick—Rs. 3,630 per mile.

The most important point, which is really the whole secret of *pise' de terre* building is good ramming. If soil of the right consistency is used, in shallow layers as described, and the ramming is well and truly done, very durable walls and buildings can be made.

Should cracks appear in the blocks a few days after they are finished, it is a sure sign that the percentage of clay in the soil is too high, and should be reduced by blending.

I have been asked whether white ants will damage these walls. I can only say that over ten years ago about 50 ft. of wall, with no foundation, was built here. It has remained totally exposed to the weather ever since, and irrigation water often flows right up to its base. There is no sign at all of the presence of white ants. A few weeks ago a small section was cut out (after considerable heavy labour with pick-axes) and the interior of the wall was found to be almost as hard and solid as rock, with no signs of white ants, or other damage.

CITRUS GROWING IN WESTERN AUSTRALIA*

INTRODUCTION

CITRUS fruits have been cultivated by man for hundreds of years and although oranges are not mentioned specifically in very early history it is more than probable that the legendary "Golden Apple of Hesperides" was none other than the common garden orange. Here in Western Australia there were at least a few orange trees grown by the early settlers, no doubt from the pips of imported fruits, but there were very little, if any, general plantings until the eighties of last century. There are still trees of these early plantings along the banks of rivers in the older settled areas. Some of the first commercial citrus groves were in the Metropolitan area and as far out as the Guildford, Cannington, Armadale and Hills districts near Perth. They were all of the seedling orange or what we now term "Common Orange" type for it was not till the end of the last century or the beginning of this one that the navel and late Valencia types made their appearance here.

As the State's population grew the planting of citrus increased and during the last forty years there have been periodic fluctuations, sometimes approaching a mild boom, in citrus plantings, until at the present time orange production ranks second only to apple growing in Western Australia's fresh-fruit growing industries.

The following table shows the areas planted and the yield of the various kinds of citrus during the year :

1938–39.

	Area Planted.	Yield.
	Acres.	Bushels.
Oranges	2,585 ..	322,350
Mandarins	141 ..	17,319
Lemons	422 ..	63,139
Other citrus	36 ..	3,248
Total ..	3,184	406,056

The harvesting period for navels, and most other oranges, extends from May to November, but the late Valencias which usually mature in October may in a few favoured districts be kept on the trees till the following April so that fresh oranges can be had throughout the year without the necessity for storage.

* By R. C. Owen, Horticultural Adviser, in the Journal of the Department of Agriculture, Western Australia, December, 1940.

Lemons too are cropping throughout the year but local mandarins and grapefruit are off the market for several months, and the latter fruit has on occasions been imported from California and Palestine during the last few years.

KINDS AND VARIETIES OF CITRUS

There are many species belonging to the citrus family, but only a few are valuable commercially. Those cultivated in this State include :—

1. Oranges *Citrus aurantium.*
2. Mandarins *C. Nobilis.*
3. Lemons *C. Limonium.*
4. Pomeloes (including grapefruit) *C. decumana.*
5. Kumquots *C. Japonica.*

In each of these there are many varieties, but of latter years there has been a strong tendency to limit the number of varieties to the few which can be grown commercially and which satisfy the requirements of the consuming public. This is particularly so with oranges for twenty or thirty years ago any variety, whether Navel, Valencia, Joppa, Queen, Siletta, or even seedling types would command a price, and the seedlings, being more prolific, were probably more profitable than the better class varieties. At the present time, however, any varieties other than navels and late Valencias are classed as " common oranges " and the return to the grower is usually low. In spite of this there are still a number of those out-of-date varieties planted every year and though these might be valuable in marginal areas where a local demand exists, the commercial grower would be wise to plant only those varieties which the public requires.

The following is a brief description of the more popular varieties, but it must be remembered that the qualities vary considerably according to the district in which they are grown, the soil, moisture, and cultural methods employed.

ORANGES

Washington Navel.—Fruit large, solid and heavy, skin smooth and of fine texture, orange to orange red in colour with the navel marking usually not prominent. Pulp juicy, with little rag, good flavour, seedless. The tree is a strong grower when young, a good and prolific bearer and generally assumes a squat roundish outline when full grown. Foliage dark green in colour.

There are also numerous sub-varieties of navels which have originated as sports from the parent. Included in these are the " Grovelly ", " Thompson's Improved ", " Navelencia ", " Golden Nugget ", and " Australian Navel ". For the most part these have not the all-round good qualities of the Washington and some, particularly the " Australian Navel ", are definitely inferior.

Probably the best known sub-variety is *Thompson's Improved.* Fruit somewhat similar in appearance to the Washington. Skin texture very smooth but not necessarily thin, navel scar may be prominent. Pulp crisp but less juicy than the Washington with a tendency to dry out at the stem end. Matures early and is only valuable in some of the early districts.

Valencia Late.—Fruit medium large, roundish oval, skin smooth and moderately thin, yellow orange to orange in colour. Has a tendency to revert to a green colour, if left hanging on the trees. Pulp acid till fully ripe, solid, juicy, with only few seeds. Ripens in the spring and in some districts can be left on the trees till the following April. Old trees have an inclination to bi-annual bearing. Tree vigorous grower with dark green foliage, more upright in growth than the Washington Navel.

MANDARINS

Trees are generally smaller in growth and foliage than the orange. They are very hardy and bear good crops of small to medium large thin-skinned fruit quite distinct in appearance and flavour.

Emperor.—Fruit medium to large, roundish, irregular and flattened. Skin brittle and somewhat puffy when fully ripe, colour yellow. Pulp fairly fine, juicy and of good flavour. Tree vigorous and upright with large dark green leaves. Good bearer. With age there is a tendency to produce a mixture of large and small fruits in the one year. Medium early.

Beauty of Glen Retreat.—Fruit medium to large, solid, skin smooth and thin. Colour orange to orange red ; skin usually tightly attached to the pulp. Very little rag. Pulp firm, juicy and when ripe is sweet. The fruit colours well before ripening and should not be marketed till the pulp is sweet. Tree vigorous and tends to form a dense head unless thinned out. Very prolific and fruit needs thinning on a heavy crop. Midseason.

Thorny.—One of the best flavoured of all mandarins. Fruit small to medium large according to size of crop and vigour of the tree. Roundish flattened, skin fine, tight and pale yellow in colour. Pulp fine and juicy. Tree moderately vigorous but tends to become dense and bushy. Midseason.

Imperial.—One of the earliest maturing mandarins on the market. Fruit medium in size, roundish flattened, skin fairly smooth and thin, yellow in colour. Pulp moderately fine and juicy. Tree upright and vigorous when young, may be only light cropped in some districts. As it matures its fruit early in the season it needs adequate summer moisture to fill out the fruits before the winter rain.

LEMONS

Lemons are usually vigorous growers and bear fruit throughout the year. They are less resistant to frosts and should have plenty of summer moisture in order to fill out the fruit during the dry months. The winter crop—often the heaviest—is usually sold in bulk for factory purposes, but the summer and in-between crops should be cured and sold in case lots.

Lisbon.—Fruit medium large in size, long oval shape, skin yellow and moderately smooth, pulp fine grained and juicy ; strongly acid and has few seeds. Tree strong and vigorous, prolific, carrying its fruit practically throughout the tree.

Eureka.—Fruit medium size, good quality, skin bright yellow, smooth and thin, pulp juicy and acid. Tree hardy and prolific, but not so dense in foliage. Much of the fruit is carried on the ends of long growths and is not so well protected from sunburn. Practically thornless.

Villa Franca.—Fruit medium to large oblong and slightly pointed at blossom end, pulp juicy and nearly seedless. Skin bright yellow and thin. Tree hardy and prolific, almost thornless, foliage strong and abundant.

GRAPEFRUIT

Grapefruit.—Is a sub-species of the pomelo and so called because of the tendency to set its fruit in bunches. The fruit are fairly large, 3 5 inches in diameter, of roundish flattened shape, pale lemon yellow in colour. The pulp is regarded as being very wholesome and refreshing, and possessing tonic properties. The fruit may be eaten fresh and has become popular as a breakfast delicacy. It may be used for making fresh-fruit drinks and also for marmalade. In the latter respect it is replacing the Seville orange.

There are several varieties of grapefruit including Triumph, Fosters and Marsh's seedless. The last-named is by far the most widely planted here and has proved itself a strong, vigorous grower, and very prolific. The fruit is carried throughout the tree and usually the best quality fruits are those borne on the inside. Matures from May onwards and in selected districts may be carried on the tree till Christmas time.

KUMQUOTS

Kumquots.—Are a dwarf species of citrus and a native of Japan. They are very hardy and prolific. Tree is very bushy with small, yellowish green leaves. Very ornamental. Fruit is small—about the size of a small apricot. There are two varieties grown—a round and an oval-shaped fruit. The round type is only suitable for marmalade, but the oval type is excellent for preserving. The demand for this class of fruit is only limited.

Soil.—The recognised citrus-growing districts in the West, range from Mooliabeenie-Bindoon and Chittering in the hills and foothills some forty miles north of Perth, Kalamunda and other centres in the Darling Range eastward, through Gosnells, Armadale, Serpentine, Harvey to Boyanup, Donnybrook and Capel on the coastal plain and over a hundred miles south of Perth. Apart from the three first mentioned districts where citrus culture is the main activity in the fruit-growing pursuit, citriculture is often combined with the growing of stone-fruits and in some places with apples.

Citrus fruits generally are indigenous to those tropical and subtropical regions of Asia and the islands of the Pacific where the climate is equitable and the rainfall is sufficient. The trees prefer a deep well drained loamy soil and they need adequate moisture throughout the year. They will not thrive in shallow undrained soils nor in districts where frosts are frequent and severe. In many of the inland districts of America, Africa and Palestine, and also in parts of the Eastern States of Australia, oranges and other members of the citrus group are now grown in areas that were formerly little better than desert regions.

The moisture problem has been overcome by large irrigation schemes and the frost hazard controlled by artificial heating. In Western Australia, however, the market requirements do not as yet warrant planting in districts other than those naturally suited to the trees or where local irrigation plants can be cheaply installed.

Undoubtedly the most important environmental factors in citriculture, are soil, moisture and temperature, and while the latter two can be controlled within limits by artificial means, the suitable soil is often the limiting factor to the areas planted. In this State oranges and lemons have been planted over a wide range of soil types and in many adverse soil conditions and although the trees have shown their adaptability by making good growth over a number of years, it is only those planted on the deep, well-drained and well-manured soils of the medium to lighter types, that have maintained their growth, vigour and productivity for thirty years and more. Contrary to general beliefs the citrus trees are not naturally of a shallow rooting habit, for although the finer feeding roots are mostly on the surface regions the heavier roots range outwards and downwards to a considerable depth. They will not, however, penetrate heavy clay subsoil or compacted hardpans nor will they persist below the permanent water table. Heavy soils do not as a rule produce large or long-lived trees but the fruit is often of excellent quality. The lighter soils may not be naturally so rich in plant foods, but they allow of extensive root development and any lack of fertility can be corrected by the application of manures and organic matter. Good deep loams and lighter soils also allow of better and quicker drainage and so approach the ideal for citrus growing.

Prospective growers who contemplate establishing a citrus orchard should choose a district which has proved satisfactory for the growth of that kind of fruit, or a district which has a rainfall of at least 30–35 inches and a fairly mild winter temperature. If a sufficient permanent supply of fresh water is available the natural rainfall figures are not important. The choice of the actual site must be governed not only by the suitable soil but also the natural protection afforded from the prevailing winds and severe frosts. Although the surface soil will give an indication do not rely solely on appearances but by means of a soil auger, test the soil and subsoil to a depth of four to five feet. Avoid those areas where a heavy clay subsoil comes near the surface, also shallow soils overlying cemented hardpan or rock. Deep sands and gravelly washes are also objectionable because they lack fertility and have a poor water holding capacity. The surface soil may be sandy provided the subsoil is of a heavier nature, for a light surface soil facilitates tillage, allows free entry of water and does not cake after irrigation.

When preparing the ground for the citrus orchard great care is necessary to see that all large roots are removed to the depth of several feet; this is particularly important if the original timber is marri, blackbutt or other trees which favour the growth of that root-rotting fungus *Armellaria melia* which is so fatal to citrus.

After clearing, the land should be broken up to a depth of ten to twelve inches, and provided the soil is suitable there is not much object in going deeper. Any

areas showing hardpan may be broken up by means of a subsoil plough or in extreme cases by explosives. If at all possible it is desirable to have the land cleared for at least a year prior to the planting so that the numerous small roots will have rotted away before the young trees are planted. The extra time and care taken in thoroughly preparing the land is by no means wasted for citrus respond to good treatment and the resultant strong and even growth throughout the plantation will make it well worth while.

DRAINAGE

Adequate drainage is very important in citrus growing and although many orchards in this State have sufficient natural drainage there are others which need more and deeper drains. All citrus trees dislike cold and waterlogged soils and even if the actual surface soil does not suffer from excess water and become waterlogged there is every possibility that the water level will rise close to the surface during the rainy season. There may be only a small section of the orchard affected, perhaps an outcrop of rock or impervious soil prevents the free passage of water, thus causing a boggy patch, or again there may be a saucer-like depression which collects seepage. The only way to ascertain the need for putting in drains is by actual observation, and if test holes, three to four feet deep are dug in likely places throughout the orchard any serious rise in the water table can be noted during the wet season. A temporary rise after excessive rainfall is not serious but if the water remains within three feet of the surface for more than a week, that part of the orchard would be benefited by more or deeper drains. Where there is plenty of depth of soil drains may be five feet deep ; in most cases, however, 3 feet 6 inches to 4 feet deep drains are sufficient provided they are not too far apart. For the sake of economy arrange the drains to effect the maximum drainage with the minimum length ; allow sufficient fall to provide a free flow of water but avoid too much slope if there is a danger of scouring.

To facilitate cultivation and also to prevent the soil from drying out during the summer all drains in the orchard should be covered in. Burnt clay or cement concrete tile drain-pipes, although expensive, are easy to lay and give good service ; where suitable rock is available a good stone drain can be put in at relatively low cost. Box drains made of timber, when constructed in a workmanlike manner, will give from thirty to forty years of service, but the makeshift drain of saplings, blackboys, or temporary materials, generally give trouble and are often only a waste of time and labour.

PLANTING

After the orchard site is cleared, broken up and drained it is ready to lay out in preparation for planting the trees. The usual systems of lay-out are :—

(1) *The Square System* where the trees in the rows are the same distance apart as the rows themselves. This allows of two ways of cultivation at right angles to each other, it is easy to set out and is suitable for all but the steeper slopes.

(2) *The Septuple System* where trees are equidistant from each other and in groups of seven-six trees forming a hexagon with one tree in the centre. This system allows of three ways of cultivation at angles of 60° to each other, but in no case is the width of cultivation as wide as the distance the trees are apart. The septuple lay out is very suitable for planting hillsides where it may avoid working straight up and down the slope. With the same distance between the trees it allows 15 per cent. more trees to the acre than does the square system but of course each tree has approximately that much less feeding space at its disposal. Contour planting is now being practised in other parts of the world in an endeavour to avoid soil erosion.

There has been some controversy about the most suitable distance to allow between trees when planting citrus ; some favour twenty feet whilst others advocate distances up to 30 feet. The writer considers that twenty feet between trees is suitable for most mandarins and other varieties having upright or dwarf habits of growth, but 24 feet or more is necessary for the larger growing orange and lemon trees. Where the soil is good and the water supply ample all the space is needed to accommodate the top growth, whereas if the soil is poor or the moisture limited the extra distance provides a bigger store of plant food moisture.

The best time for planting citrus trees is when the weather is moderately cool but not when the soil is cold and wet. If the trees are available, autumn planting during April and early May is suitable in frost-free districts ; where the trees are not procurable till later or in regions where winter frosts occur, the spring planting in August and early September gives the best results. Prior to planting, remove any dead or injured roots by severing with a sharp knife or secateurs, and have the holes fertilized and prepared to receive the tree. Mix any manure well into the soil and below the root area, and so avoid the possibility of putting the roots in direct contact with artificial manures. Where chemical manures have been applied in close contact with the roots, it is no uncommon thing for the trees to remain dormant for months, and though some may eventually grow, many gradually die out. When setting the tree, spread the roots well out and press the soil closely about them. Do not plant too deeply—deep planting does not mean a deep rooting tree—it may lead to the loss of the tree through *Collar-rot* or *Gummosis* of the trunk. If the trees are set in the ground at the same depth as they originally stood in the nursery, or even slightly shallower, there should be no trouble.

After planting it is a good idea to tie the tree to a stake and hold it firm against winds, and also if the trunk is wrapped with straw, paper or bagging, it will protect it from the direct rays of the sun until such time as the tree provides sufficient shade for itself.

Through the summer the main concern is to control weed-growth and conserve soil moisture. Keep the surface soil near the tree in a good tilth but do not cultivate deep enough to disturb the roots or to dry out the soil at length.

SELECTION OF TREES

When planting citrus trees due care should be taken to see that none but healthy and vigorous plants are selected. This is a matter of extreme importance as if the trees are unhealthy or weakly in constitution they are unlikely to give the grower satisfaction.

Nowadays citrus are all " worked " or budded trees and as the propagation of these is a specialized trade, it is in most cases better to leave it to the experienced nurseryman. He can usually be relied upon to supply good healthy trees on suitable stocks, but to give him a chance to supply your requirements and to avoid possible disappointment, it is always advisable to place your order some months in advance of planting time.

Of late years there has been a move towards standardization of citrus types and by " Bud Selection " much is being accomplished. " Bud Selection " means that the buds from which the trees were propagated were taken from parent trees selected for bearing good regular crops of fruit, true to type, and free from hereditary weakness. Bud selected trees may vary under different environmental conditions, but where conditions are alike they produce groves of even trees bearing regular type fruits. It is too much to expect even bud selected trees grown under unsuitable conditions to produce fruit of equal quality as the same trees grown under congenial conditions.

Apart from the selection of buds much can be done by the nurseryman in culling out unsuitable root stocks and only using those which are strong and vigorous. The rough lemon or citronella rootstock is favoured by most nurserymen as it is a vigorous grower and produces a good sized tree in less time than most other stocks. It is quite satisfactory under a wide range of soil conditions but some claim that the sweet orange stock is preferable for, although slower in starting, it eventually produces a large and long lived tree.

If the old sweet orange seedlings still growing in many parts of the State are any indication the sweet orange stock is very suitable for the majority of our citrus areas.

Other stocks sometimes used are the sour orange or Seville, which are said to resist collar-rot or gummosis even under wet conditions. They are strong rooting, but must have a deep and rich soil.

Citrus trifoliata is also used and is supposed to have a dwarfing effect on the tree. The few older trees I have seen on this stock are rather unsatisfactory.

For general plantings, trees carrying one year's growth from the bud are suitable, although older trees may be used provided they have been suitably " balled " to protect them during transport from the nursery. They are, of course, more expensive than the younger trees. When replacing trees in established orchards it is quite a good idea to purchase the trees one or two years in advance and establish them in a suitable nursery on the place. With careful attention they will make good growth and at a suitable time can be transplanted without suffering any ill effects, and will then have a better chance of competing with the older established trees around them. With care, even old trees can be transplanted, for the writer has successfully shifted

trees over thirty years of age and established them in positions among full bearing trees. In this case, however, it was necessary to cut the top growth back in proportion to the roots removed in transplanting.

CULTIVATION

General cultivation methods in citrus growing are very similar to those carried out in any other orchard, the main objects being to maintain the soil humus by growing weeds or special green crops during the winter or wet season and ploughing them in so that the green material is well rotted before the dry season sets in, and to conserve the moisture and keep down weeds during the dry months of the year. It is much easier to maintain or even build up the humus content of the soil right from the start than to replace the organic matter after the soils have become worked out. As the trees increase in size there is less space in which to grow the green crop, and also the evergreen trees cause a dense shade and limit the growth of the crop during the short days of the winter.

Commence the building-up process from the time the orchard is planted, and when the trees are full grown there will be ample reserves of organic matter, so the maintenance will be much easier. Green crops of the legume family—beans, peas, lupins, tares, &c., not only maintain the humus content but also greatly augment the nitrogen supply of the soil and so make it possible to reduce the quantity of expensive nitrogenous manures used. New Zealand blue lupins or tick beans when planted early in the season make excellent green manure crops ; they are easy to plough in and readily decompose in the soil. Whatever crop is grown, even if only natural weed growth, the secret of success is to plough it in early enough so that it decays and allows the cultivation to be completed before the dry weather sets in.

Avoid excessive summer cultivation when the soil is dry, because not only is it unnecessary from the point of view of moisture conservation, but it tends to break up the soil particles and cause loss of humus. This leads to the soil becoming " snuffy " when it will not absorb water readily, and is likely to be lost by erosion. The dust menace too is considerable, and this in its turn will choke the leaf pores and also favour the breeding of citrus red scale.

(*To be continued*)

THE HYBRIDIZATION OF TROPICAL GARDEN PLANTS*

WHEN pollen is placed on the stigma of a flower, the individual grains of pollen produce tubes which grow down into the ovary and there each fertilize an egg-cell. The result is the development of a fruit containing seeds. Many flowers are fertilized by their own pollen, while others are so arranged that they must receive pollen from other individuals. But in either case, seeds cannot be produced unless there is union of the male element of the pollen with the egg-cells in the ovary. If now pollen from one flower should fall on the stigma of a different kind of flower, various different things may happen. The pollen may remain inactive ; or it may grow but fail to fertilize ; or it may fertilize the ovules and so seeds may be produced. In the last case the seeds will be of mixed parentage, and when sown will produce plants which are unlike either parent. We call them hybrids.

Hybridization is thus a means of producing new kinds of plants ; and it has been very much used in the last two centuries to produce garden plants which are different from their wild ancestors, the plants which nature gives to us. This process has naturally been carried on more extensively in temperate regions than in the tropics, and a large proportion of temperate garden plants are of hybrid origin. This is especially true of herbaceous plants, which are short-lived and so give quicker results than the more slow-maturing woody plants. But many groups of woody plants (such as Rhododendrons) have been hybridized extensively in temperate countries and have given rise to large series of beautiful new forms.

Hybridization in tropical plants has been a more recent development, and many of our plants are still as nature gave them to us—beautiful, it is true, but often lacking the variety we might have, and lacking possible combinations of useful characters such as beauty of form combined with freedom of flowering. In this article is given a brief survey of some of the results of the hybridization of ornamental plants for tropical gardens, and also some suggestions for possible new developments. But first some general remarks may be helpful.

The reader who is not familiar with the elements of plant breeding and the principles concerned is recommended to consult a little book by Mr. W. J. C. Lawrence, Curator of the John Innes Horticultural Institution, entitled *Practical Plant Breeding* (G. Allen and Unwin, 2nd ed. 1939, price 3*s*. 6*d*.). This gives a simple introduction to the subject and a description of the technique of plant breeding. Any Malayan gardener who would like to try his hand at

* By R. E Holttum, M.A., F.L.S., Director of Gardens, S. S. in *The Malayan Agri-Horticultural Association Magazine*, Vol. XI., No. 1, January, 1941.

the work of producing new plants for Malayan gardens would find the book most helpful. There are few more fascinating hobbies than work of this kind, and elaborate equipment is not needed (except in special cases such as orchids). The requirements are careful observation, careful manipulation, and patience; and the rewards may be great.

Hybrids can of course be produced only between plants which are nearly related to each other. Botanists have classified plants into groups on their external characters, and it is found in practice that plants which botanists recognize as nearly related will breed together; but one can never be certain without trying. Sometimes plants grouped in different genera are inter-fertile, while different species classed as belonging to the same genus may be inter-sterile. Then we have also to consider the fertility of the hybrids when they are produced. Some hybrids produce good seeds, and some do not. Those that do not can sometimes be propagated from cuttings, and so they can be preserved and multiplied if they are useful; but they cannot be used for further breeding.

Hybrids that are fertile when mated together or crossed back with either parent present a further problem: their off-spring is varied, and the more different the parents producing the hybrid, the more varied the offspring at the second generation. This means of course that we cannot usually propagate a hybrid by seeds if we wish to preserve its particular characters; but it also means that at the second and later generations we may expect a range of novelties such as the first hybrids do not show. This variation provides material for selection; out of the many varieties the plant breeder selects the best for propagation by cuttings or for further breeding. The less desirable varieties are discarded. There are many qualities which must be considered in evaluating hybrids: suitability to local conditions and freedom of flowering are just as important as beauty of form and colour.

On the practical side there is not space here to deal fully with the technique of pollination, but a few notes may be included. In some flowers pollination is easy; *e. g.*, Gloriosa. Here the anthers are large and easy to handle and the stigma is easy to reach without disturbing the rest of the flower. In other flowers pollination is difficult; the stigma may be hidden so that the flower must be cut to reach it; the parts may be small and delicate so that they are difficult to handle without damage; and it is often necessary to open buds to remove stamens prematurely to prevent self-pollination. Every kind of flower presents its own problems, and we must study its development carefully before we can find the best way of dealing with it. The other important practical problem is breeding material. It is essential first to procure and bring into cultivation side by side as many different species or varieties as possible of the group of plants to be worked on; the greater the number of different original subjects, the greater the possibilities of breeding.

GROUPS WHICH HAVE ALREADY BEEN HYBRIDIZED

Orchids are the group of ornamental tropical plants which have received the greatest attention from hybridizers; but it is only in recent years that work

has been carried out in the tropics with a view to securing hybrids suitable to tropical gardens. For a discussion of this subject, see this Magazine, Vol. X., p. 41. Orchids are easy to pollinate, but the minute seeds need special treatment, and the seedlings require years to mature. The results, however, have been spectacular, and there are great possibilities in current developments in Malaya and Java.

Cannas.—There is a paper on the hybridization of Cannas in this Magazine, Vol. VI., p. 21, and a further note in Vol. VII., p. 23. Most of the Cannas which we grow in Malaya to-day originated by hybridization in Europe and North America. The parent species were obtained both from Asia and from America, four being principally concerned, and the first large-flowered hybrids of modern type were produced in Italy in the eighteen-nineties. To-day the number of hybrids is very large. The technique of cross pollination is not difficult (see details in the paper above quoted) and hybrid plants can be made to flower in four months from pollination. It is not likely that amateur breeders will produce anything of startling novelty, though quite possible that good new forms specially suited to local conditions may be developed. Mr. Milsum and others have produced good new hybrids in Malaya.

Hibiscus.—Every gardener knows the variety that exists in this genus. In this Magazine, Vol. IX., p. 88, are some notes on the origin of Hibiscus hybrids and on the possibility of producing more locally. The hybrids at present existing have chiefly been developed in Hawaii in the present century. More should be produced in Malaya, and attempts should be made to introduce other species into the hybrid complex. We still want more Hibiscus which are really free-flowering under Malayan conditions.

Bougainvilleas.—In this genus of South American plants hybridization began naturally between species cultivated in the Canary Islands about the beginning of the present century. Artificial hybrids were not produced until 1918, by Mr. W. N. Sands at St. Vincent. More recently, such hybrids have been raised at Calcutta and elsewhere, and natural hybridization has occurred extensively where several varieties or species have been grown together in Queensland, Mauritius and other suitable climates. There is no doubt that considerable further development is possible but it does not seem easy to produce seeds in Malaya. For an account of the present position, see this Magazine, Vol. VIII., p. 69.

Rhododendrons.—One does not usually think of these as tropical garden plants ; but hybrids of Rhododendrons from the mountains of the Malayan region were made under glass in Europe more than sixty years ago and are still fine greenhouse plants. They are not suited to the Malayan lowlands, but they are under trial at our highlands, where they should be further developed, and it seems very likely that hybrids of our lowland Malayan *Rhododendron longiflorum* may be useful pot plants in the lowlands. Much more work both on mountain and lowlands species in Malaya is desirable, and there are great possibilities.

Lantanas.—It is only in the last two or three years that we have had any considerable number of Lantana hybrids in Malaya. The common species,

which has run wild as a weed and is a pest in many countries, is never sufficiently free-flowering to be a useful garden plant ; but some of the hybrids are very free-flowering and also of bright and distinctive colours. They are easy to grow and are becoming very popular. Artificial pollination is difficult, as the flowers are small ; but as any seeds must be hybrids, they will produce plants which are likely to be different from their parents. The cultivation of Lantana seedlings is quite interesting, as one may turn up something new and worth preserving by vegetative propagation. It seems that the common Lantana was introduced from South America to Europe before the end of the 17th century, and to the Eastern tropics early in the 19th century. Various colour varieties have long been known, but I have not found any information as to the origin of the present range of hybrids. I believe that many of them were produced in France, but our best seeds came from California. The best pure yellow hybrid we have at present is called " Drap d'Or " ; it has been introduced to Singapore from Ceylon and from Hong-Kong. I should be interested to know of its origin.

Water-Lilies.—Tropical and sub-tropical water-lilies have been much hybridized in Europe and America, and we have some of the results in cultivation in Malaya. There are certain groups of species that do not interbreed, so that the possibilities are limited in some directions ; for example, it appears to be impossible to cross the blue water-lilies (*Nymphaea stellata*, &c.) with the white or pink ones of the group *Nymphaea lotus*. It is doubtful whether much useful further hybridization is possible in Malaya ; it would be best first to secure more of the hybrids produced elsewhere.

Plumeria (Frangipanni).—For remarks on raising plants from seeds, see this Magazine, Vol. X., p. 99. Artificial hybridization is difficult in this genus, but seeds produced naturally are usually the result of crossing (presumably by insects) and so are hybrids which may give rise to novelties. The range of colour and form is not large ; but some of the existing hybrids are very handsome. Plumerias are plants of Mexican origin, and have been cultivated for centuries. I have no information as to the origin of the finer pink hybrids to be found to-day. It appears that a considerable number are grown in Honolulu, and perhaps were produced there.

Begonias.—There are an enormous number of species of Begonia, native in the warmer parts of all continents. They have been cultivated as greenhouse plants in Europe since the 18th century, and in more recent times the wonderful large-flowered tuberous Begonia hybrids have been developed for outdoor cultivation in temperate countries. In Malaya we grow principally certain " foliage " Begonias, originating from species of the hill forests of north-eastern India, and " flowering " Begonias, chiefly of tropical American origin. There are also native Malayan Begonias in our forests, some of them worth cultivating. Very little hybridizing of Begonias has been done in Malaya, and there are great possibilities for the development of new forms specially suited to our climate, particularly new flowering varieties for bedding. Male and female flowers in Begonias are separate, which simplifies pollination problems ; but the pollen appears to be scanty and the flowers must be carefully studied to find the appropriate time to pollinate.

Zephyranthes.—The beautiful little Crocus-like flowers of this genus, native of the West Indies, are well known in Malayan gardens. A little hybridizing has been done, notably by Mr. Milsum in Malaya, but more might well be attempted. Pollination is easy, the seeds ripen in about three weeks and germinate almost at once. It is desirable to introduce the large *Z. aurea* (a deep yellow, the flower twice the size of the common kinds) into the scheme of hybridization. I have twice failed to do this, but further attempts should be made, especially using *Z. aurea* as pollen parent.

Hippeastrum.—For a note on these "Red Lilies" of tropical American origin, see this Magazine, Vol. X., p. 71. The first garden hybrid Hippeastrum was made in 1799, and since then a large number more, mostly for greenhouse culture in temperate regions. Modern hybrids make a magnificent display, but most are unsuited to lowland Malayan conditions. As pointed out in the note above mentioned, it is however possible to hybridize these plants here, so that we can select the seedlings which are most free-flowering in our climate. Since the note was published, several more free-flowering bulbs of large-flowered kinds have been found in Singapore, and more seedlings have been sown. There is great scope here for the amateur, as pollination and seed-raising are easy; but it takes time to raise a seedling to flowering.

Crotons.—The variegated leaves of these shrubs adorn all our gardens, and potted Crotons are also very handsome. They are native from the Moluccas east-wards to the Pacific, and the indigenous peoples of those parts had selected many races for ornamental cultivation before the visits of Europeans. In the 19th century many such varieties were introduced to Europe for greenhouse culture, but whether they were further hybridized artificially I do not know. Probably new varieties arise from time to time from chance seeds. Male and female flowers are separate, so that cross pollination should not be difficult, but I have never heard of an attempt locally. The experiment would be an interesting one.

Acalypha.—Several species of this genus of shrubs with variegated leaves are also well known in Malayan gardens; they belong to the same family as Crotons and come from the same region. The cultivated Acalyphas are not so striking as the Crotons, but they are quite ornamental, and in the hills some are very brightly coloured. Little if anything has been attempted at artificial hybridization until recently; I have lately heard that this has been done in North Queensland, and have received some cuttings of new hybrids through the Botanic Garden at Brisbane. It is too soon to say how good they are; but at least their existence indicates possibilities of further development within the genus.

Ixora.—Ixoras are found in every Malayan garden and are among the few shrubs we can rely on to flower throughout the year. The kinds with large heads of orange red flowers are mostly of Malayan origin; those with smaller heads of red or yellow flowers mostly from further north. The latter have certainly been hybridized, but I do not know where or when. There are other Malayan Ixoras not yet cultivated which might also be used, and nearly all are very variable, even in the wild. There is little doubt that the genus Ixora offers great scope for the hybridist, and cross pollination ought not to be difficult.

The range of tones is from scarlet through orange to yellow and white ; and the range of shape and size of flowers and size of heads is also fairly considerable.

Caladiums.—These well-known tuberous Aroids with prettily variegated leaves originally came from South America. They were brought into cultivation in Europe in the latter part of the 18th century and have since been very much hybridized. The common kinds have run wild in Malaya and might almost be classed as weeds ; but the finer kinds demand careful pot cultivation. There are so many kinds that it is unlikely that anyone would raise any striking novelties by further hybridizing, at least on the stock available in Malaya ; but hybridizing is doubtless possible and would be interesting for anyone who wishes to specialize in this group. I have no experience of the practical problems involved.

Anthurium.—Several species of this group of Aroids are cultivated for their beautiful foliage or for their flowers, the latter including the red *Anthurium Andreanum* and its hybrids which have been developed in Europe during the past sixty years. The coloured part of the plant is called the spathe ; it is a kind of leaf joined to the inflorescence. The flowers proper are closely placed upon a solid spike which stands out like a finger from the base of the spathe. These red Anthuriums make very handsome plants, though of rather fierce colour. The finest kinds have large spathes of varied shades from brilliant crimson to white. It appears that new varieties have been raised from seed in Bangkok ; and there is no reason why the same should not be done here. At present, few kinds are grown in Malaya. Pollination is easy, as the female flowers of an inflorescence are mature first, the stamens opening afterwards. The seeds develop slowly, and form irregular protuberances on the inflorescence. They appear to take some time to germinate.

TROPICAL GENERA WHICH HAVE BEEN LITTLE OR NOT AT ALL HYBRIDIZED

Crinum.—These lily-like plants were described in this Magazine, Vol. V., p. 160. The local species set fruits freely and there seems no reason why local hybrids should not be raised. The large pink Crinum which we call C. *amabile* is very handsome and the large white-flowered C. *giganteum* is our most beautiful lily-like plant. More variety in this group would certainly be useful.

Gloriosa.—*Gloriosa superba* is very common in local gardens and most useful for decorative purposes. There exist also other species, notably *G. Rothschildiana* and another which we grow under the name *G. virescens* var. *grandiflora*. So far as I know, they have not yet been hydridized locally, and the attempt would be worth while. Mr. Laycock in Singapore has raised *G. Rothschildiana* from seeds.

Solanum.—There are now several interesting and varied species of this genus in cultivation in Malaya ; for example, the potato tree and the pretty climbers (*S. Wendlandi* and *S. Seaforthianum*) with lavender-blue potato-like flowers. These have never been hybridized, though related species such as the tomato, potato and brinjal have been. In such a large and diverse group it seems likely that good and distinctive new garden plants might arise.

Clerodendron.—In this genus of shrubs, small trees and scrambling climbers, we have a number of interesting and showy species which have never been hybridized. We have flowers of red, white and blue shades, and a variety of form in the inflorescence. It is unlikely that all of these varied species are freely interfertile, but some of them probably are, and the experimental crossing would be well worth undertaking.

Lagerstroemia.—We in Malaya only know the tree-Lagerstroemias, the beautiful *Bungor* trees which are now being extensively planted by our roadsides (see this Magazine, Vol. VII., p. 101 and Mr. Corner's book). The Crepe Myrtle also exists in some Malayan gardens, and flowers to some extent, especially in the north (see Vol. VII., p. 105) but is rarely seen by most of us. We now also have in cultivation the Kedah Bungor (*L. floribunda*) and also a beautiful and distinct species from Thailand (*L. Loudoni*). The common *Bungor* itself exists in a number of varieties with flowers of different shades. Here we should have material to work on (if we can get them to flower together), and the prospect of hybrid Bungor trees is a fascinating one.

Jatropha.—For an account of the species of this genus in local cultivation see this Magazine Vol. VIII., p. 3. These species are sufficiently varied and interesting to make crossing worth a trial. Male and female flowers are separate, and large enough to handle easily, so that the technique ought not to be difficult.

Ipomoea.—The annual Japanese Morning Glories have been much hybridized and many beautiful shades produced during the past fifty years. These grow quite well in Malaya, but are short-lived and do not compare in usefulness as garden plants with the perennial species which grow for years without needing renewal. These permanent plants are mostly natural species that have not been hybridized. Whether they will cross or not, I do not know ; but if only *I. Horsfalliae* (wine red) could be made to hybridize with any other species we might have a whole range of new plants.

Cassia.—It is reported that in Honolulu the beautiful yellow *Cassia fistula* (" Golden Shower ") has been hybridized with pink species. I know of no other records of hybrids in this genus ; but the species are so numerous, and mostly set seed so freely, that success seems quite likely. For an account of this genus, see Mr. Corner's paper in this Magazine, Vol. V., p. 37.

Bauhinia.—If Cassias could be hybridized, why not Bauhinias ? Here we have another attractive and distinctive group of plants with several species already in local cultivation. Few hybrids seem to have been produced in the family Leguminosae, so perhaps the prospects here are not very bright ; but trials should be made.

Barleria.—The common mauve and white garden Barlerias are attractive, though not really showy. There are also other species such as *B. involucrata* and B. *lupulina*. Attempts at crossing these would be worth while.

Stigmaphyllon.—The attractive yellow-flowered climbers of this tropical American genus were described in this Magazine, Vol. VII., p. 153. There are now five species in cultivation here, and all set seed occasionally. They all have yellow flowers, but are sufficiently different to be worth crossing if this is possible.

Passiflora.—This is a very large genus containing some 300 species, mostly from the tropics of South America. Apart from those which have edible fruits there are some very attractive garden flowers among them, several of which are already in local cultivation. They are easy to pollinate but do not set fruit readily. However, if one grew the various species side by side and carried out a large number of pollinations, success is quite likely, and the results would certainly be interesting and attractive.

It would be possible to extend this list considerably. Enough has however been written to indicate that the possibilities of this work are great, and the scope for experiment almost unlimited. When tropical plants have received the attention which has been devoted to temperate plants, our gardens will be transformed. But we must always remember that the Malayan climate is peculiar in its uniformity, and that if we want to be sure of selecting the hybrids most suited to our needs, we must raise them here.

COMPOST: ITS PREPARATION AND USES*

IT is a well-known fact that continual cultivation of the soil eventually leads to a complete depletion of plant nutrients. In the past this depletion was counteracted by bringing virgin soils under cultivation or by applying the excreta of animals. The modern farmer uses chemical fertilizers, but experience has proved that the application of these inorganic fertilizers must go hand in hand with application of organic material in some or other form.

Organic matter is indispensable in soils for the following reasons :—

(*a*) It usually contains all the important plant nutrients. While, in the past, all attention was given to the three major elements, viz., potash, phosphate and nitrogen, it is to-day evident that certain other elements such as copper, manganese, boron, &c., are equally important. Only very small quantities of these are needed by the average plant, but still they are most essential There is reason to believe that most of these trace elements are present in ordinary plant residues.

(*b*) Organic matter improves the physical condition of a soil in that it gives a better structure to heavy clay and coarse sandy soils.

(*c*) Soils with a fair amount of organic matter are better able to absorb and retain water.

(*d*) The incorporation of organic matter into sandy soils enables such soils to absorb and retain soluble plant nutrients with ease.

It is impossible and impracticable to return to the soil all the organic matter which it loses, but by regular applications of organic matter total deterioration can be prevented. Since organic matter is largely derived from plant tissues, it is important to know how a plant is constituted, and what happens in the process of decay.

COMPOSITION OF THE PLANT

The main groups of components are the following :—

(*a*) Water-soluble substances such as carbohydrates, starches, &c.
(*b*) Cellulose and hemi-cellulose.
(*c*) Lignin.
(*d*) Proteins.
(*e*) Fats, plant oils and waxes.
(*f*) Mineral matter.

From the point of view of soil fertility, all these groups are important, but we shall deal only with the carbohydrates, proteins and lignin.

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* By I. S. Perold, Professional Officer (Agricultural Chemistry), Stellenbosch-Elsenburg College of Agriculture in *Farming in South Africa*, Vol. XVI., No. 179, February, 1941.

The carbon : nitrogen ratio.—When analysing fresh plant material, it is invariably found that it contains much more carbon than nitrogen. The former is derived from the carbohydrates, whereas the latter is derived from the proteins.

The ratio of carbon to nitrogen is most important as regards soil fertility. If plant matter, such as wheat straw, with a wide carbon : nitrogen ratio, is incorporated into a soil, the productivity of the soil in the initial stages is lowered. Only after a period of six months or even longer, *i.e.*, after most of the straw is decomposed, will such a soil be able to produce a normal crop. It is thus evident that a negative period sets in during the process of decay, and this negative period is dependent upon the activities of certain micro-organisms in the soil. Since these micro-organisms need carbon as well as nitrogen for their normal existence, they start attacking the carbohydrates and proteins of the organic matter immediately after it has been incorporated.

In the case of carbohydrates, carbon becomes available and carbon dioxide and water are set free. The carbon dioxide dissolves in the soil moisture to form very dilute carbonic acid which renders reserve mineral matter in the soil more available.

Apart from carbon these micro-organisms also require nitrogen. If the supply of carbohydrate in the soil greatly exceeds that of the protein, the latter is broken down in sufficient quantities to satisfy their nitrogen requirements only. When all the available carbohydrates have been used up they attack the proteins, and only at this stage will nitrogen make its appearance in the soil.

The micro-organisms responsible for the splitting up of the carbohydrates and proteins prefer a neutral medium, and are predominantly aerobic in nature, *i.e.*, they require oxygen for normal development. The negative period in most soil types, especially in regions with a high rainfall, will therefore be fairly long.

In the preparation of compost conditions are created whereby the carbon : nitrogen ratio is narrowed in a relatively short period, with the result that there is practically no negative period when the manure is incorporated into the soil.

The humification of lignin.—Lignin is the parent material of the real humus. Unlike the carbohydrates and proteins, lignin is not decomposed through microbial action, but can be transferred into humus only through oxidation. Consequently an excess of oxygen is required for this process, and since most soils lack an excess of air, humification will be relatively slow.

Every observant farmer knows with what difficulty oak leaves decompose in soils, but he also knows that such leaves, when completely decomposed, have a beneficial effect in the physical condition of the soil. The reason for this is the inadequate supply of air in the soil. In the preparation of compost provision is made for sufficient air with a view to accelerating humification.

ARTIFICIAL DECOMPOSITION OF PLANT MATERIAL

After the Great War of 1914–1918 fertilizers were very expensive with the result that scientists directed their attention to the preparation of artificial

manure. Richards and Hutchinson in England were pioneers in this respect with their well-known " Adco ". Their method was based on the principle of accelerating the decomposition of organic material in heaps by the addition of certain chemicals. However, this is rather expensive, and under present conditions it cannot be recommended in this country.

In 1931 Howard and his associates at Indore, India, introduced a new and valuable method whereby plant material is transformed *outside the soil* into available organic manure. In a treatise " The Waste Products of Agriculture " by Howard and Wad, the method is described in detail. It is dependent on three important factors which are required by the microbes responsible for the decomposition of the plant material, viz. (*a*) air, (*b*) moisture, and (*c*) a neutral or sweet medium.

The method differs from the " Adco " process in so far as no chemicals or chemical fertilizers are added to the plant material, but only small quantities of manure and soil.

In South Africa conditions are such that the method followed in India cannot be adopted in full. The method in use is based on the principles introduced by Howard and Wad, but the technique is different.

MATERIALS FROM WHICH COMPOST IS MADE

(1) All waste products on the farm such as old bedding from stables and kraals, grass leaves, twigs and prunings, chaff, straw, bushes, shrubs and weeds are used. Where the plant material is still green, it should not be used immediately, but first allowed to wilt.

Most of the above-mentioned materials can be packed in regular layers, but difficulty is encountered with prunings from vines and fruit trees. Owing to the shape of these materials turning is very cumbersome, and decomposition in the heap proceeds very slowly. These difficulties can be overcome in two ways : Firstly a very cheap type of mill can be used for cutting the material into 6-inch lengths before taking it to the compost heap, or the material can be kept over for a year before composting it. The easiest method is to stack the fresh prunings in a heap for a year. In this heap the material is attacked by insects which make it brittle, and this makes handling easier.

(2) Apart from the above-mentioned materials, limited quantities of manure are required for making compost. Manure is always contaminated with microbes, and thus serves as a source of inoculation for the various layers of plant material. On many farms the tractor has superseded draught animals to a large extent, and there will be a shortage of manure. This can be supplemented by increasing the bedding in the stable of the few animals still on the farm. At Elsenburg excellent results have been obtained with a mixture of manure and urine-impregnated straw in a ratio of approximately two parts by weight of manure to three parts by weight of straw. The manure used can be that of any animal or bird.

In many parts of the Union, especially in the western Cape Province, Karroo manure is consistently used in excessive quantities, with the result that black alkali is becoming a problem. By buying less Karroo manure and using it

for compost-making the farmer will render a service not only to himself, but also to the future owners of the farm. Care must be taken that the manure used is not too old. Since the ratio of manure to farm residues is approximately 1 to 12, the brak danger due to the incorporation of large amounts of Karroo manure is practically eliminated.

(3) In addition to the plant residues and manure a limited amount of loamy surface soil is required. The functions of the soil are firstly to supply micro-organisms, and secondly to absorb beneficial gases. Since the microbes responsible for decomposition require a neutral medium, it is essential to use a sweet or neutral soil. If such a soil is not obtainable some wood-ash or agricultural lime must be used with it.

ESTABLISHING THE COMPOST HEAP

A compost heap can be established on the surface or in a shallow pit about 1 foot deep. The pit system is more expensive and is recommended only in cases where prevailing winds cause excessive drying out of the heaps.

The heap should be 15 to 18 feet wide and can be of any convenient length; preferably not exceeding 45 feet. In order to prevent too great a pressure on the lower layers, it is advisable that the height be not more than 3 to 4 feet.

The procedure in establishing the heap is as follows: Put down plant residues to a height of about 15 inches and cover this with a layer of manure—about 1 inch. Next put on a uniform layer of surface soil—½ to 1 inch—and if the soil is acid, spread some lime or wood-ash evenly over it. The second and third layers are put on in exactly the same way, and the last layer is well covered with about 1 inch of soil. The different layers are watered separately but not to such an extent that the heap is drenched.

After 6 to 12 hours a rise in temperature in the heap will set in and after 24 hours it ought to be about 130° F. or 55° C. The rise un temperature is caused by the rapid decomposition of the organic material by micro-organisms, and will be maintained as long as sufficient air and moisture are present. For this reason it should be seen to that no trampling down of the heap takes place and that it does not dry out. An easy way of ascertaining whether the heap is warm enough and whether it has sufficient moisture, is to push an iron standard into it The standard when withdrawn should be hot to the touch, and should have a film of moisture on its surface. If this is not the case, water must be added to the heap. At Elsenburg the experience has been that it is hardly ever necessary to water the heaps during the winter months, and for this reason it is advisable to make compost in winter in the western Cape Province. There is also the added advantage that the compost is ready at the end of winter, *i.e.*, at a time when it is most needed by the plants.

Turning the heap.—The compost heap should be turned for the first time after about a month, and thereafter every three weeks. After three or four months it should be ready. In cases where an excess of woody material is used, the rate of decomposition will be slow. To accelerate the decomposition, it is advisable not to use woody materials exclusively, but to mix them with

straw, shrubs, bushes or grass. Even in cases where only straw or chaff is used, the decomposition is very uneven in the initial stages, and it is always advantageous to make a mixture of different types of materials.

In turning the heap care should be taken that the material on the outside is brought to the centre of the new heap. It is very seldom necessary to add additional manure and soil, or to cover the heap with a layer of soil when it is being turned. The main object in turning the heap is to mix the decomposing mass thoroughly, and thereby introduce sufficient air. Occasionally it happens that no rise in temperature sets in, and in such cases a small amount of manure can be added when turning the heap.

KRAAL COMPOST

On many farms it is the custom to cart shrubs and straw into the kraal, where it mixes with the manure and becomes impregnated with urine. The objections to this system are firstly that the mass is trampled down too firmly, resulting in a very slow humification of the lignin. The manure from such kraals will always contain undecomposed materials. Secondly, there is a big loss of nitrogen from such kraals.

The defects of this system can be remedied by making compost in the kraal, and the easiest way of accomplishing this is as follows: cart the shrubs, bushes, straw, prunings and other waste materials into the kraal to a height of 2 to 3 feet, and keep the animals in the kraal until the mass is trampled down to approximately $1\frac{1}{2}$ feet. Now remove the animals to another kraal and divide the trampled-down mass in the kraal into heaps 15 to 18 feet wide, and of any convenient length. Cover the different heaps with about an inch of soil, apply water if necessary, and leave until the first turning. Thereafter proceed as described previously. In cases where sufficient materials are at hand, a temporary kraal can be built of fencing materials.

THE CHEMICAL COMPOSITION OF COMPOST

The composition of the final product will depend on the nature of the materials used. The following figures were obtained at Elsenburg from compost made from wheat straw, bluegum twigs and leaves, old thatch, grass and weeds.

Sample No.	Composition on the Dry Basis			
	Moisture content.	Total nitrogen.	Total potassium oxide.	Total Phosphorus pentoxide.
	Per cent.	Per cent.	Per cent.	Per cent.
1	43·7	0·73	0·99	0·44
2	42·9	0·69	1·04	0·45
3	46·2	0·63	0·88	0·29
4	42·9	0·83	1·05	0·39
5	42·7	0·69	0·92	0·36

The average composition is therefore as follows: 0·71 per cent. nitrogen, 0·976 per cent. potassium oxide and 0·386 per cent. phosphorus pentoxide. Suppose now that 20 tons of compost (= $11\frac{1}{4}$ tons of dry material) be applied per morgen, then the actual weight of major plant nutrients is: 160 lb. nitrogen, 220 lb. potassium oxide and 87 lb. phosphorus pentoxide. These plant

nutrients are not essentially in the same form as in the well-known fertilizers sulphate of ammonia, muriate of potash and superphosphate, but it is important to note that 800 lb. sulphate of ammonia, 367 lb. muriate of potash and 458 lb. superphosphate must be applied to get the weight of major plant nutrients contained in 20 tons of this compost. Since the availability of the plant nutrients in compost is very high, and the nitrogen is present as organic nitrogen, the value of compost cannot be over-estimated.

A comparative test carried out in the Cape Flats recently proved that different kinds of vegetables responded much better to compost than to ordinary manure, especially in the initial stages of growth.

THE COST OF MAKING COMPOST

It is practically impossible to estimate the cost of making compost, since too many factors must be taken into account. The first of these is the value of the plant residues. Many farmers will argue that no value ought to be given to weeds and other waste products, since these must be removed from the lands. However, this reasoning is incorrect, since expensive labour is employed for doing this work.

On the average farm there is an abundance of coarse materials, but the finer materials are usually lacking, which often makes it necessary to go to the expense of cutting grass or bushes, or even buying chaff or straw. This will undoubtedly increase the cost, but at the same time the value is also increased. Every farmer must therefore decide for himself whether he is entitled to go to the expense of buying extra materials.

The second important factor to be considered is the cost of transporting the materials to the composting site. The actual cost is usually not very high since most farmers have their own means of transport. The maintenance of these, however, must be taken into account and the final product debited with this amount. It is important to note that the carting of materials must not be done at times when more important activities on the farm require attention.

The water used in the composting process is another important factor. If it is obtained from permanent source such as a river or a dam, the cost will not be excessive, but if it is to be pumped from a borehole the cost will be slightly higher.

As is evident from the following table, labour is the most important factor in determining the cost of compost. This table represents a detailed analysis of the cost of 14 tons of compost made at Elsenburg :—

	£	*s.*	*d.*
Two mules for 2 days at 1*s.* 6*d.* per mule per day ..	0	6	0
One waggon for 2 days at 2*s.* per day	0	4	0
Cost of labour for 4 applications of water	0	2	0
Estimated cost of water used	0	1	0
Cost of labour for 3 turnings	0	5	0
Six labourers for 2½ days at 3*s.* per day	2	5	0
	3	3	0

Therefore cost per ton is 4*s.* 6*d.*

These figures are probably too high, since the same labour and implements are employed for making more than 14 tons of compost at a time.

THE APPLICATION OF COMPOST

The amount of compost to be applied will depend largely on the materials from which it is made. If these materials are of inferior quality, the nutrient content will be low, and more compost will be required per morgen.

The rate of application is also dependent upon the type of soil. Loams and sandy loams usually require less than sandy soils and heavy clays.

The third factor in this connexion is the type of crop for which the compost is intended. For vines and fruit trees 10 to 15 tons per morgen ought to be sufficient, but for vegetables the amount must be increased to 15 to 20 tons per morgen.

Many farmers do not know how much a ton of manure is, and it may, therefore, interest them to know that 1 cubic yard of compost with 40 per cent. moisture weighs from 1,300 to 1,500 lb.

Stable manure usually contains a fair amount of straw, and can, therefore, be applied with stable forks. Compost on the other hand is so fine that it passes between the teeth of a fork, and the farmer may find it necessary to use spades for broadcasting it. The degree of fineness is important in that it indicates when the compost is ready, and secondly the finer material is much cheaper to handle than manure.

When compost is applied, it must not be left for long periods in small heaps on the land, since this results in a decrease in value. This also applies to stable manure. It should be broadcast and ploughed under as soon as possible. If it so happens that the compost is ready, but that the farmer cannot apply it immediately, he should rather leave it in the original heap. To prevent loss, this heap should be well trampled down and covered with a layer of soil.

CONCLUSION

The aim of compost-making is most decidedly not to get rid of manure, but to supplement it. Compost-making is of the greatest importance to the farmer who is forced to buy manure, since it enables him to use the little manure he has to the best advantage, and it also enables him to change unavailable plant nutrients in the form of plant residues into available plant nutrients in a comparatively short time.

Chemical fertilizers are expensive and nobody can foretell what the position will be in the near future. For this and many other reasons the value of compost can never be overrated. Not only the farmer, but also his family, will benefit through compost, since it is an excellent method of combating flies. Manure pits and dung heaps are ideal places for breeding flies, but in a compost heap, this is hardly possible owing to the high temperatures.

RUBBER RESEARCH SCHEME (CEYLON)

MINUTES OF THE FIFTY-FIFTH MEETING OF THE RUBBER RESEARCH BOARD HELD AT DARTONFIELD ESTATE, AGALAWATTA, AT 10 A.M. ON MONDAY, JANUARY 20, 1941.

Present.—Mr. M. Crawford (in the Chair) ; Mr. T. Amarasuriya ; Mr. W. P. H. Dias, J.P. ; Mr. L. M. M. Dias ; Mr. G. E. de Silva, M.S.C. ; Mr. T. C. A. de Soysa ; Mr. J. D. Farquharson ; Mr. L. P. Gapp ; Mr. F. H. Griffith ; M.S.C. ; Mr. R. C. Kannangara, M.S.C. ; Mr. J. C. Kelly ; Mr. F. A. Obeyesekera, and Mr. N. D. S. Silva, O.B.E., J.P.

Mr. T. E. H. O'Brien, Director, was present by invitation.

Apologies for absence were received from Messrs. R. J. Hartley ; S. Phillipson (Deputy Financial Secretary) ; E. C. Villiers, M.S.C., and E. W. Whitelaw.

1. MINUTES.

Draft minutes of the meeting held on October 28, 1940, which had been circulated to members, were confirmed and signed by the Chairman.

2. BOARD.

The Chairman reported that as Acting Director of Agriculture he had assumed duties as Chairman of the Board with effect from November 11, 1940.

He welcomed Mr. S. Phillipson, C.C.S., Deputy Financial Secretary, who had been deputed by the Financial Secretary to represent him on the Board with effect from December 7, 1940.

The Chairman referred to the valuable services rendered to the Board by Mr. C. H. Collins during his long period of office and proposed that the Board's appreciation of his services be placed on record. Carried with applause. The Director said he was personally very grateful to Mr. Collins for advice given on matters referred to him.

3. EXPERIMENTAL COMMITTEE.

Recommendations made at meeting held on December 17, 1940 :—

Labour force at Dartonfield.—Decided to provide 4 cottages for Ceylonese labourers. The Committee was asked to submit estimates for 2 single and 2 semi-detached cottages. It was also decided to provide kitchen hearths in the line rooms at Dartonfield and Nivitigalakele at a cost of Rs. 1,380.

Accommodation for Junior staff.—Decided to build one additional junior staff bungalow at Dartonfield during the current year, at a cost of Rs. 4,157.

Junior Staff.—Decided to postpone consideration of the appointment of a Chemical Assistant owing to the impending departure of the Chemist on military service.

A Sub-Committee was appointed to consider the salaries and terms of service of the junior staff. The following were nominated to serve on the Committee :—The Deputy Financial Secretary, Mr. F. A. Obeyesekera, Mr. L. P. Gapp, and the Director.

Extension of selection and breeding work.—Consideration was given to a memorandum embodying proposals for the extension of selection and breeding work, involving an expenditure of approximately Rs. 300,000, spread over a period of 12 years. After discussion it was decided to apply to Government for an area of approximately 1 square mile of crown land to be leased to the Research Scheme, to enable the extended programme of work to be undertaken.

Rubber Planting in dry Districts.—Arising from an enquiry on the subject of Rubber planting in dry districts the Director was instructed to prepare a memorandum embodying the Board's view that it is unsound to encourage the planting of Rubber in any district in which the climate is not well suited to this crop.

4. SMALLHOLDINGS COMMITTEE.

Recommendations made at meeting held on January 10, 1941 :—

Co-operative Societies.—Decided to give the fullest support to proposals for encouraging the development of Co-operative Societies for Rubber Smallholders, and that a trial be made in the first place by endeavouring to establish a Rubber section in an existing society.

COAGULANTS.

Consideration was given to the situation arising from the use of sulphuric acid as an adulterant for acetic and formic acids, and as the basis of proprietary coagulants which are sold to smallholders at an unfair price. Decided to recommend, as has been done in Malaya, that regulations be issued prohibiting the import of sulphuric and other mineral acids, except under licence. The recommendation was approved that the Rubber Instructors should try to persuade village dealers to stock acid supplied by firms whose product is known to be satisfactory, and should advise smallholders to buy their acid from dealers who do so.

It was also decided to recommend that steps should be taken to have stocks of acetic and formic acid brought under control while supplies are plentiful, in order that price or other restrictions could be imposed without delay in the event of a shortage developing at any time.

Rubber rollers for Smallholders.—Decided to import two rubber rollers from Malaya for trial, at a cost of Rs. 250.

5. ACCOUNTS.

(*a*) Statement of Receipts and Payments of the Board for the quarter ended September 30, 1940, was approved.

(*b*) Dartonfield and Nivitigalakele accounts for August, September and October, 1940, were tabled.

(*c*) Fixed Deposits—

Renewals.—The Chairman reported the renewal of the following fixed deposits :—

(1) Rs. 35,000 at the Mercantile Bank of India renewed with the Bank of Ceylon at $1\frac{3}{4}$ per cent. interest for 12 months from December 23, 1940.

(2) Rs. 50,000 at the National Bank of India, Ltd., renewed at $1\frac{3}{4}$ per cent. interest for 12 months from December 31, 1940.

New Deposit.—Reported that Rs. 10,000 was placed in fixed deposit at the Bank of Ceylon at $1\frac{3}{4}$ per cent. interest for 12 months from December 16, 1940.

6. STAFF.

(*a*) Reported that Mr. T. E. H. O'Brien had returned to the island on December 1, and resumed duties as Director with effect from December 4, 1940.

(*b*) *Re-engagement of Mr. R. K. S. Murray.*—Reported that Mr. Murray's period of engagement was due to expire on December 31, 1941. Mr. Murray's application for leave from May 1 (approx.) was approved and it was decided that he be offered re-engagement on the terms laid down for officers recruited from abroad.

(*c*) *Mr. M. W. Philpott.*—Reported that permission had been granted to Mr. M. W. Philpott to volunteer for military service, in accordance with the Board's decision of June 10, 1940. Mr. Philpott had been accepted for service in the R. A. F. and would shortly be leaving Ceylon.

(*d*) *Junior Staff.*—Reported the following appointments :—

(*a*) Mr. A. K. J. Abeysinghe as a clerk in the head office.

(*b*) Mr. S. D. David as assistant estate clerk.

7. CESS COLLECTIONS.

After discussion it was decided not to proceed with the proposals for stabilizing the Board's income from cess collections, in view of the adverse opinion expressed by one of the associations to which the proposals had been circulated for comment.

8. PROGRESS REPORT.

The Acting Director's report for the 3rd Quarter, 1940, was adopted.

9. PATENTS.

Arising from a recommendation made at the Conference of Directors of Rubber Producers' Research Organizations, held in 1940, the Board considered and decided on general lines of policy in regard to the provision of patent protection for useful discoveries made by Research Scheme officers.

10. PUBLICATIONS.

The 3rd Quarterly Circular for 1940 was tabled.

Research Laboratories,
Dartonfield,
Agalawatta.

February 10, 1941.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED JANUARY 31, 1941

Province, &c.	Disease	No. of Cases up to date since Jan. 1, 1941	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Rabies	1	1	..	..	..	1
Colombo Municipality	Rabies	7	7	7	..	..	..
Central	Rabies	12	12	..	..	..	12
	Bovine Tuberculosis	3	3	..	..	..	3
Southern	Rabies	1	1	..	..	..	1
Eastern	Foot-and-mouth disease	23	..	3	..	20	..
	Rabies	2	2	..	..	..	2
North-Western	Anthrax	15	15	15	..	..	..
	Contagious Mange	8	4	..	2	6	..
Sabaragamuwa	Piroplasmosis	1	1	..	1	..	..
	Rabies	1	1	1	..	..	..

Department of Agriculture,
Peradeniya, February 25, 1941.

M. CRAWFORD,
Deputy Director of Agriculture (Animal Husbandry)
and Government Veterinary Surgeon.

METEOROLOGICAL REPORT, JANUARY, 1941

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	88·4	+0·3	70·5	—0·2	74	93	4·4	6·98	13	—
Anuradhapura ..	84·5	+1·7	72·3	+3·4	78	95	5·6	4·33	15	— 1·38
Badulla ..	78·0	+1·9	65·3	+1·6	76	92	5·8	7·11	18	— 3·44
Batticaloa ..	82·4	+1·1	74·6	+1·0	82	90	5·4	12·89	16	— 0·88
Colombo ..	87·1	+0·9	72·7	+0·8	74	93	5·6	1·22	8	— 2·81
Diyatalawa ..	73·1	+1·4	58·1	+0·6	79	94	6·6	2·73	20	— 3·61
Galle ..	84·8	+1·0	74·3	+1·6	78	93	4·6	3·12	12	— 0·52
Hakgala ..	66·5	+0·2	50·9	—0·7	82	90	6·2	7·24	16	— 4·89
Hambantota ..	84·8	—0·1	74·1	+1·6	80	90	5·2	1·70	10	2·00
Jaffna ..	83·6	+0·8	73·8	+1·7	76	90	6·0	7·31	9	— 2·97
Kandy ..	84·8	+1·8	67·4	+0·2	70	90	5·8	3·97	12	+ 2·69
Kurunegala ..	87·3	+1·0	71·2	+1·6	70	93	5·2	2·99	8	— 1·88
Lunuwila ..	88·6	+1·3	72·6	+1·8	74	95	4·6	1·68	3	— —
Mannar ..	82·7	—0·9	75·3	+1·2	80	88	5·0	4·19	9	0·23
Nuwara Eliya ..	66·9	—0·7	48·9	+2·3	73	90	6·0	2·62	11	+ 4·12
Puttalam ..	86·3	+0·9	72·0	+2·1	78	98	5·2	2·49	11	— 1·09
Ratnapura ..	89·8	+0·7	72·5	+1·5	76	95	5·8	4·61	10	— 1·86
Talawakele ..	75·2	+1·5	55·5	—0·3	65	85	5·4	1·91	7	—
Trincomalee ..	81·7	+1·3	75·3	+0·1	80	88	5·4	8·15	17	— 0·55

The rainfall for January was below normal over the greater part of the Island. Slight excesses occurred in the north and east.

The largest deficits were Upper Ohiya 7.98 inches, West Haputale 7·80 inches, Kanankadu 7·50 inches and Ledgerwatte 7·35 inches. The only excesses over 5 inches were Horaborawewa 6·79 inches, Alutnuwara 5·33 inches and Vavuniya 5·10 inches.

Rainfall totals of over 30 inches were recorded at 3 stations, St. Martin's Upper 32·48 inches, Hendon 32·16 inches and Lugal-oya 31·00 inches. Two stations, Flensburg and Veppankulam, had no rain.

There were altogether 18 daily falls of 5 inches and over reported, the largest being 9·20 inches at Korahena on the 8th. The majority of the large falls occurred on the 11th.

North-east monsoon weather prevailed during the month. Practically the whole of the rain fell during the first 17 days, the last fortnight being almost dry. The wettest periods were the 4th to the 8th, the 11th and the 12th. There was a fair amount of thunder reported during the course of the month.

Temperatures were again above average. The highest shade temperature recorded was 94·7° at Ratnapura on the 31st, while the lowest temperature was 37·3° at Nuwara Eliya on the 30th. Humidity was on the whole in excess. Cloud amounts were generally near normal. Surface winds were on the whole above average strength, the prevailing direction being north-east.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.